INDIAN REGISTER OF SHIPPING

CLASSIFICATION NOTES

Approval of I.C. Engines

July 2022

IRCLASS
Indian Register of Shipping

CLASSIFICATION NOTES

Approval of I.C. Engines

July 2022

Foreword

This Classification Note is prepared in order to provide a single document of reference to all concerned for all activities / procedures involved in approval of I.C. Engines and their components including Turbochargers. The various Sections and Appendices also provide a generic flow of documents between engine designer, IRS Plan Approval Centre, engine builder/licensee and IRS's Surveyors.

This document is applicable to any IC engine(s) for which type approval certification is dated on or after 01 July 2022. The "date of application for type approval" is the date of documents accepted by IRS as request for type approval certification of a new engine type or of an engine type that has undergone substantive modifications in respect of the one previously type approved, or for renewal of an expired type approval certificate.

Engines with an existing type approval on 1 July 2022 are not required to be re- type-approved. Engine certification for these engines will be carried out accepting the existing type approval and related submitted documentation in place of that required by this Classification Notes until the existing type approval expires or the engine type has undergone substantive modifications at which point the type approval is to be renewed in accordance with this Classification Notes.

Requirements for Factory Acceptance Trials and Shipboard Trials of I.C. Engines are indicated in the Rules for Construction and Classification of Steel Ships.

The requirements for I.C. Engines given in this Classification Notes apply to diesel engines also.

This Classification Note supersedes IRS document "Type Approval Certification Scheme for Machinery Manufactured by Mass Production System".

Section 5 of this Classification Note addresses the type approval requirements of trunk piston internal combustion engines supplied with low pressure natural gas as fuel. Such engines can be either dual fuel engines or gas fuel only engines.

Section 6 of this Classification Note addresses the approval requirements for methanol fueled engines. These requirements can be further refined, based on experience of approval and operation of methanol fueled engines.

This edition of the Classification Note supersedes "*Approval of I.C Engines - December 2021"*

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TABLE 1 – CORRIGENDA INCORPORATED IN THIS EDITION

Clause	Subject/ Amendments
Section 1 : Documentation	
1/ Table 1	Reference to FMEA reports approval is deleted.
Appendix 3	Reference to IMO Resolutions is corrected.

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Contents

Section

Section 1

Documentation

1.1 Scope

This section gives an overview of the type approval and certification process of I.C. Engines. The documents necessary to approve a diesel engine design for conformance to the Rules and for use during manufacture and installation are listed. Further, the document flow between engine designer, IRS Plan Approval Centre, engine builder/licensee and IRS's Surveyors is indicated.

1.2 Definitions

Definitions relating to approval of diesel engines are given in Appendix 1.

1.3 Overview

1.3.1 Approval process

1.3.1.1 Type Approval Certificate

A type approval certificate is to be obtained by the engine designer for each type of engine that is required to be approved. The process details for obtaining a type approval certificate are indicated in 1.4. This process consists of the following:

- drawing and specification approval,
- assessment of conformity of production,
- approval of type testing programme,
- type testing of engines,
- review of the obtained type testing results, and
- evaluation of the manufacturing arrangements,
- issue of a type approval certificate upon satisfactorily meeting the Rule requirements.

1.3.1.2 Engine Certificate

Each diesel engine manufactured for a shipboard application is to have an engine certificate. The certification process details for obtaining the engine certificate are indicated in 1.5. This process consists of the engine builder/ licensee obtaining design approval of the engine application specific documents, submitting a comparison list of the production drawings to the previously approved engine design drawings referenced in 1.3.1.1, forwarding the relevant production drawings and comparison list for the use of the Surveyors at the manufacturing plant and shipyard if necessary, engine testing and upon satisfactorily meeting the Rule requirements, the issuance of an engine certificate.

1.3.2 Document flow for diesel engines

1.3.2.1 Document flow for obtaining a type approval certificate

1.3.2.1.1 For the initial engine type, the engine designer is to prepare the documentation in accordance with requirements in Tables 1 and 2 and forward to IRS, according to the agreed procedure for review.

1.3.2.1.2 Upon review and approval of the submitted documentation (evidence of approval), it would be returned to the engine designer.

1.3.2.1.3 The engine designer is to arrange for a Surveyor to attend an engine type test and upon satisfactory testing IRS would issue a type approval certificate.

1.3.2.1.4 A representative document flow process for obtaining a type approval certificate is shown in Appendix 2, Figure 1.

1.3.2.2 Document flow for engine certificate

1.3.2.2.1 The engine type is to have a type approval certificate. For the first engine of a type, the type approval process and the engine certification process (ECP) may be performed simultaneously.

1.3.2.2.2 Engines to be installed in specific applications may require the engine designer/ licensor to modify the design or performance requirements. The modified drawings are to be forwarded by the engine designer to the engine builder/ licensee to develop production documentation for use in the engine manufacture in accordance with Table 3.

1.3.2.2.3 The engine builder/ licensee is to develop a comparison list of the production documentation to the documentation listed in Tables 1 and 2. An example comparison list is provided in Appendix 4. If there are differences in the technical content on the licensee's production drawings/ documents compared to the corresponding licensor's drawings, the licensee is to obtain agreement to such differences from the licensor using the template in Appendix 5.

If the designer acceptance is not confirmed, then the engine is to be regarded as a different engine type and is to be subjected to the complete type approval process by the licensee.

1.3.2.2.4 The engine builder/ licensee is to submit the comparison list and the production documentation to IRS according to the agreed procedure for review/approval.

1.3.2.2.5 IRS would return documentation to the engine builder/ licensee with confirmation that the design has been approved. This documentation is intended to be used by the engine builder/ licensee and their subcontractors and attending Surveyors. As the attending Surveyors may request the engine builder/ licensee or their subcontractors to provide the actual documents indicated in the list, the documents are necessary to be prepared and available for the Surveyors.

1.3.2.2.6 The attending Surveyors, at the engine builder/ licensee/ subcontractors, are to issue product certificates as necessary for components manufactured upon satisfactory inspections and tests.

1.3.2.2.7 The engine builder/ licensee is to assemble the engine and test the engine with a Surveyor present. An engine certificate would be issued by the Surveyor upon satisfactory completion of assembly and tests.

1.3.2.2.8 A representative document flow process for obtaining an engine certificate is indicated in Appendix 2, Figure 2.

1.3.3 Approval of diesel engine components

Components of engine designer's design which are covered by the type approval certificate of the relevant engine type would be regarded as approved, whether manufactured by the engine manufacturer or sub-supplied. For components of subcontractor's design, necessary approvals are to be obtained by the relevant suppliers (e.g. exhaust gas turbochargers, charge air coolers, etc.).

1.3.4 Submission format of documentation

IRS would determine the documentation format: electronic or paper, based on prior agreement. If documentation is to be submitted in paper format, the number of copies would be indicated by IRS.

1.4 Type Approval Process

The type approval process is to consist of the steps in 1.4.1 to 1.4.4. The document flow for this process is shown in Appendix 2, Figure 1.

The documentation, as far as applicable to the type of engine, to be submitted by the engine designer/ licensor to IRS is listed in Tables 1 and 2.

1.4.1 Documents for information Table 1

Table 1 lists basic descriptive information to provide IRS an overview of the engine's design, engine characteristics and performance. Additionally, there are requirements related to auxiliary systems for the engine's design including installation arrangements, list of capacities, technical specifications and requirements, along with information needed for maintenance and operation of the engine.

1.4.2 Documents for approval or recalculation Table 2

Table 2 lists the documents and drawings, which are to be approved by IRS.

1.4.3 Design approval/ appraisal (DA)

DA's are valid as long as no substantial modifications have been implemented. Where substantial modifications have been made the validity of the DA's may be renewed

based on evidence that the design is in conformance with all current Rules and statutory regulations (e.g. SOLAS, MARPOL). See also 1.4.6.

1.4.4 Type approval test

A type approval test is to be carried out in accordance with Section 2 and is to be witnessed by IRS Surveyors.

The manufacturing facility of the engine presented for the type approval test is to be assessed in accordance with Section 3.

1.4.5 Type approval certificate

After the requirements in 1.4.1 through 1.4.4 have been satisfactorily completed, IRS will issue a type approval certificate (TAC).

1.4.6 Design modifications

After IRS has approved the engine type for the first time, only those documents as listed in the tables, which have undergone substantive changes, will have to be resubmitted for consideration by IRS.

1.4.7 Type approval certificate renewals

A renewal of type approval certificates will be granted upon:

1.4.7.1 Submission of information in either 1.4.7.1.1 or 1.4.7.1.2.

1.4.7.1.1 The submission of modified documents or new documents with substantial modifications replacing former documents compared to the previous submission(s) for DA.

1.4.7.1.2 A declaration that no substantial modifications have been applied/ undertaken since the last DA was issued.

1.4.8 Validity of type approval certificate

The duration of validity of the type approval certificate will be five (05) years. The type approval certificate will be invalid if there are substantial modifications in the design, in the manufacturing or control processes or in the characteristics of the materials unless approved in advance by IRS.

1.4.9 Document review and approval

1.4.9.1 The assignment of documents to Table 1 for information does not preclude possible comments by IRS.

1.4.9.2 Where considered necessary, IRS may request further documents to be submitted. This may include details or evidence of existing type approval or proposals for a type testing programme in accordance with Section 2.

1.5 Certification Process

The certification process consists of the steps in 1.5.1 to 1.5.5. This process is illustrated in Appendix 2, Figure 2 showing the document flows between the:

- engine designer/ licensor,
- engine builder/ licensee,
- component manufacturers,
- IRS plan approval centre, and
- IRS site offices.

For those cases when a licensor – licensee agreement does NOT apply, an “engine designer” shall be understood as the entity that has the design rights for the engine type or is delegated by the entity having the design rights to modify the design.

The documents listed in Table 3 may be submitted by:

- the engine designer (licensor),
- the manufacturer/ licensee.

1.5.1 Document development for production

Prior to the start of the engine certification process, a design approval is to be obtained as per 1.4.1 through 1.4.3 for each type of engine. Each type of engine is to be provided with a type approval certificate obtained by the engine designer/ licensor prior to the engine builder/ licensee beginning production manufacturing. For the first engine of a type, the type approval process and the certification process may be performed simultaneously.

The engine designer/ licensor is to review the documents listed in Tables 1 and 2 for the application and develop, if necessary, application specific documentation for the use of the engine builder/ licensee in developing engine specific production documents.

If substantive changes have been made, the affected documents are to be resubmitted to IRS as per 1.4.6.

1.5.2 Documents to be submitted for inspection and testing

Table 3 lists the production documents, which are to be submitted by the engine builder/ licensee to IRS following acceptance by the engine designer/ licensor. The Surveyor is to use the information for inspection purposes during manufacture and testing of the engine and its components. See 1.3.2.2.3 through 1.3.2.2.6.

1.5.3 Alternative execution

If there are differences in the technical content on the licensee’s production drawings/ documents compared to the corresponding licensor’s drawings, the licensee must provide to the IRS plan approval centre a “Confirmation of the licensor’s acceptance of licensee’s modifications” approved by the licensor and signed by licensee and licensor.

Modifications applied by the licensee are to be provided with appropriate quality requirements. Sample format for the same is provided in Appendix 5.

1.5.4 Manufacturer approval

IRS would assess conformity of production with the Society's requirements for production facilities comprising manufacturing facilities and processes, machining tools, quality assurance, testing facilities, etc. (See Section 3). Satisfactory conformance would result in the issue of a Class approval document.

1.5.5 Document availability

In addition to the documents listed in Table 3, the engine builder/ licensee is to be able to provide to the Surveyor performing the inspection upon request the relevant detail drawings, production quality control specifications and acceptance criteria. These documents are for supplemental purposes to the survey only.

1.5.6 Engine assembly and testing

Each engine assembly and testing procedure required according to requirements of Cl. 4.13/ Pt. 4, Ch. 4 of IRS Rules and Regulations for Construction and Classification of Steel Ships are to be witnessed by the attending Surveyors, unless an Alternative Certification Scheme (ACS) meeting the requirements of Pt.1, Ch.1, Sec.4 of IRS Rules for Construction and Classification of Steel Ships; is agreed between manufacturer and IRS.

Table 1 : Documentation to be submitted for information, as applicable

No.	Item
1	Engine particulars (e.g. Data sheet with general engine information (see Appendix 3), Project Guide, Marine Installation Manual)
2	Engine cross section
3	Engine longitudinal section
4	Bedplate and crankcase of cast design
5	Thrust bearing assembly[1]
6	Frame/framebox/gearbox of cast design[2]
7	Tie rod
8	Connecting rod
9	Connecting rod, assembly[3]
10	Crosshead, assembly[3]
11	Piston rod, assembly[3]
12	Piston, assembly[3]
13	Cylinder jacket/ block of cast design[2]
14	Cylinder cover, assembly[3]
15	Cylinder liner
16	Counterweights (if not integral with crankshaft), including fastening
17	Camshaft drive, assembly[3]
18	Flywheel
19	Fuel oil injection pump
20	Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly
	For electronically controlled engines, construction and arrangement of:
21	Control valves
22	High-pressure pumps
23	Drive for high pressure pumps
24	Operation and service manuals[4]
25	FMEA (for engine control system)[5]
26	Production specifications for castings and welding (sequence)
27	Evidence of quality control system for engine design and in service maintenance
28	Quality requirements for engine production
29	Type approval certification for environmental tests, control components[6]

Notes:

1. If integral with engine and not integrated in the bedplate.
2. Only for one cylinder or one cylinder configuration.
3. Including identification (e.g. drawing number) of components.
4. Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
5. Where engines rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves, a failure mode and effects analysis (FMEA) is to be submitted to demonstrate that failure of the control system will not result in the operation of the engine being degraded beyond acceptable performance criteria for the engine.
6. Tests are to demonstrate the ability of the control, protection and safety equipment to function as intended under the specified testing conditions per Classification Note “Type Approval of Electrical Equipment used for Control, Protection, Safety and Internal Communication Systems for Use in Ships”.

Table 2 : Documentation to be submitted for approval, as applicable	
No.	**Item**
1	Bedplate and crankcase of welded design, with welding details and welding instructions[1,2]
2	Thrust bearing bedplate of welded design, with welding details and welding instructions[1]
3	Bedplate/oil sump welding drawings[1]
4	Frame/framebox/gearbox of welded design, with welding details and instructions[1,2]
5	Engine frames, welding drawings[1,2]
6	Crankshaft, details, each cylinder No.
7	Crankshaft, assembly, each cylinder No.
8	Crankshaft calculations (for each cylinder configuration) according to the attached data sheet and Classification Note : “Calculation of Crankshafts for I.C. Engines”.
9	Thrust shaft or intermediate shaft (if integral with engine)
10	Shaft coupling bolts
11	Material specifications of main parts with information on non-destructive material tests and pressure tests[3]
	Schematic layout or other equivalent documents on the engine of:
12	Starting air system
13	Fuel oil system
14	Lubricating oil system
15	Cooling water system
16	Hydraulic system
17	Hydraulic system (for valve lift)
18	Engine control and safety system
19	Shielding of high pressure fuel pipes, assembly[4]
20	Construction of accumulators (for electronically controlled engine)
21	Construction of common accumulators (for electronically controlled engine)
22	Arrangement and details of the crankcase explosion relief valve (Pt.4/Ch.4 of the Rules)[5]
23	Calculation results for crankcase explosion relief valves (Pt.4/Ch.4 of the Rules)
24	Details of the type test program and the type test report)[7]
25	High pressure parts for fuel oil injection system[6]
26	Oil mist detection and/or alternative alarm arrangements (Pt.4/Ch.4 of Rules)
27	Details of mechanical joints of piping systems (Pt.4/ Ch.2 of Rules)
28	Documentation verifying compliance with inclination limits (Pt.4/ Ch.1 of the Rules)
29	Documents as required in Pt.4/ Ch.7 of the Rules, as applicable

Notes :

1. For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
2. For each cylinder for which dimensions and details differ.
3. For comparison with IRS requirements for material, NDT and pressure testing as applicable.
4. All engines.
5. Only for engines of a cylinder diameter of 200 [mm] or more or a crankcase volume of 0.6 [m^3] or more.
6. The documentation to contain specifications for pressures, pipe dimensions and materials.
7. The type test report may be submitted shortly after the conclusion of the type test.

Table 3 : Documentation for the inspection of components and systems	
- Special consideration will be given to engines of identical design and application - For engine applications refer to Section 3 (Certification of Engine Components)	
No.	**Item**
1	Engine particulars as per data sheet in Appendix 3
2	Material specifications of main parts with information on non-destructive material tests and pressure tests[1]
3	Bedplate and crankcase of welded design, with welding details and welding instructions[2]
4	Thrust bearing bedplate of welded design, with welding details and welding instructions[2]
5	Frame/frame box/gearbox of welded design, with welding details and instructions[2]
6	Crankshaft, assembly and details
7	Thrust shaft or intermediate shaft (if integral with engine)
8	Shaft coupling bolts
9	Bolts and studs for main bearings
10	Bolts and studs for cylinder heads and exhaust valve (two stroke design)
11	Bolts and studs for connecting rods
12	Tie rods
	Schematic layout or other equivalent documents on the engine of:[3]
13	Starting air system
14	Fuel oil system
15	Lubricating oil system
16	Cooling water system
17	Hydraulic system
18	Hydraulic system (for valve lift)
19	Engine control and safety system
20	Shielding of high pressure fuel pipes, assembly[4]
21	Construction of accumulators for hydraulic oil and fuel oil
22	High pressure parts for fuel oil injection system[5]
23	Arrangement and details of the crankcase explosion relief valve (Pt.4/Ch.4 of Rules)[6]
24	Oil mist detection and/or alternative alarm arrangements (see Pt.4/Ch.4 of Rules)
25	Cylinder head
26	Cylinder block, engine block
27	Cylinder liner
28	Counterweights (if not integral with crankshaft), including fastening
29	Connecting rod with cap
30	Crosshead
31	Piston rod
32	Piston, assembly[7]
33	Piston head
34	Camshaft drive, assembly[7]
35	Flywheel
36	Arrangement of foundation (for main engines only)
37	Fuel oil injection pump

Table 3 : (Contd.)

38	Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly
39	Construction and arrangement of dampers
	For electronically controlled engines, assembly drawings or arrangements of:
40	Control valves
41	High-pressure pumps
42	Drive for high pressure pumps
43	Valve bodies, if applicable
44	Operation and service manuals[8]
45	Test program resulting from FMEA (for engine control system)[9]
46	Production specifications for castings and welding (sequence)
47	Type approval certification for environmental tests, control components[10]
48	Quality requirements for engine production

Notes :

1. For comparison with IRS requirements for material, NDT and pressure testing as applicable.
2. For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
3. Details of the system so far as supplied by the engine manufacturer such as: main dimensions, operating media and maximum working pressures.
4. All engines.
5. The documentation to contain specifications for pressures, pipe dimensions and materials.
6. Only for engines of a cylinder diameter of 200 [mm] or more or a crankcase volume of 0.6 [m^3] or more.
7. Including identification (e.g. drawing number) of components.
8. Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
9. Required for engines that rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves.
10. Documents modified for a specific application are to be submitted to IRS for information or approval, as applicable. See 1.3.2.2.2, Appendix 4 and Appendix 5.

Appendix 1 - Definitions

Term	Definition
Acceptance criteria	A set of values or criteria which a design, product, service or process is required to conform with, in order to be considered in compliance
Accepted	Status of a design, product, service or process, which has been found to conform to specific acceptance criteria
Alternative Certification Scheme (ACS)	A system, by which IRS evaluates a manufacturer's quality assurance and quality control arrangements for compliance with Rule requirements, then authorizes a manufacturer to undertake and witness testing normally required to be done in the presence of a Surveyor. The Alternative Certification Scheme as followed by IRS is detailed in Pt.1, Ch. 1, Sec. 4 of the IRS Rules for Construction and Classification of Steel Ships
Appraisal	Evaluation by a competent body
Approval	The granting of permission for a design, product, service or process to be used for a stated purpose under specific conditions based upon a satisfactory appraisal
Assembly	Equipment or a system made up of components or parts
Assess	Determine the degree of conformity of a design, product, service, process, system or organization with identified specifications, Rules, standards or other normative documents
Audit	Planned systematic and independent examination to determine whether the activities are documented, the documented activities are implemented, and the results meet the stated objectives
Auditor	Individual who has the qualifications and experience to perform audits
Certificate	A formal document attesting to the compliance of a design, product, service or process with acceptance criteria
Certification	A procedure whereby a design, product, service or process is approved in accordance with acceptance criteria
Class	Short for Classification Society (here IRS)
Class approval	Approved by a Classification Society (here IRS)

Term	Definition
Classification	Specific type of certification, which relates to the Rules of IRS
Competent body	Organization recognized as having appropriate knowledge and expertise in a specific area
Component	Part, member of equipment or system
Conformity	Where a design, product, process or service demonstrates compliance with its specific requirements
Contract	Agreement between two or more parties relating to the scope of service
Contractor	see Supplier
Customer	Party who purchases or receives goods or services from another
Design	All relevant plans, documents, calculations described in the performance, installation and manufacturing of a product
Design analysis	Investigative methodology selectively used to assess the design
Design appraisal	Evaluation of all relevant plans, calculations and documents related to the design
Design review	Part of the appraisal process to evaluate specific aspects of the design
Drawings approval/ plan approval	Part of the design approval process which relates to the evaluation of drawings and plans
Equipment	Part of a system assembled from components
Equivalent	An acceptable, no less effective alternative to specified criteria
Evaluation	Systematic examination of the extent to which a design, product, service or process satisfies specific criteria
Examination	Assessment by a competent person to determine compliance with requirements
Inspection	Examination of a design, product service or process by an Inspector

Term	Definition
Inspection plan	List of tasks of inspection to be performed by the Inspector
Installation	The assembling and final placement of components, equipment and subsystems to permit operation of the system
Manufacturer	Party responsible for the manufacturing and quality of the product
Manufacturing process	Systematic series of actions directed towards manufacturing a product
Manufacturing process approval	Approval of the manufacturing process adopted by the manufacturer during production of a specific product
Material	Goods supplied by one manufacturer to another manufacturer that will require further forming or manufacturing before becoming a new product
Modification	A limited change that does not affect the current approval
Modification notice	Information about a design modification with new modification index or new drawing number replacing the earlier drawing
Performance test	Technical operation where a specific performance characteristic is determined
Producer	See manufacturer
Product	Result of the manufacturing process
Prototype test	Investigations on the first or one of the first new engines with regard to optimization, fine tuning of engine parameters and verification of the expected running behaviour
Quality assurance	All the planned and systematic activities implemented within the quality system, and demonstrated as needed to provide adequate confidence that an entity will fulfill requirements for quality. Refer to ISO 9001:2015
Regulation	Rule or order issued by an executive authority or regulatory agency of a government and having the force of law

Term	Definition
Repair	Restore to original or near original condition from the results of wear and tear or damages for a product or system in service
Requirement	Specified characteristics used for evaluation purposes
Information	Additional technical data or details supplementing the drawings requiring approval
Revision	Means to record changes in one or more particulars of design drawings or specifications
Rules	For the purpose of this document, Rules means IRS Rules for Construction and Classification of Steel Ships
Specification	Technical data or particulars which are used to establish the suitability of materials, products, components or systems for their intended use
Substantive modifications or major modifications or major changes	Design modifications, which lead to alterations in the stress levels, operational behaviour, fatigue life or an effect on other components or characteristics of importance such as emissions
Subsupplier/subcontractor	One who contracts to supply material to another supplier
Supplier	One who contracts to furnish materials or design, products, service or components to a customer or user
Test	A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. A technical operation to determine if one or more characteristic(s) or performance of a product, process or service satisfies specific requirements
Traceability	Ability to follow back through the design and manufacturing process to the origin
Type approval	The establishment of the acceptability of a product through the systematic: 1. Evaluation of a design to determine conformance with specifications 2. Witnessing manufacture and testing of a type of product to determine compliance with the specification

Term	Definition
	3. Evaluation of the manufacturing arrangements to confirm that the product can be consistently produced in accordance with the specification
Type approval test	Last step of the type approval procedure. Test program in accordance with Section 2
Witness	Individual physically present at a test and being able to record and give evidence about its outcome

Appendix 2 - Representative Document Flow Diagrams

The document flow diagrams in this Appendix are provided as an aid to all parties involved in the engine certification process as to their roles and responsibilities. Variations in the document flow may vary in response to unique issues with regard to various factors related to location, availability of components and surveys. In any case, the text in the Classification Note takes precedence over these flow diagrams.

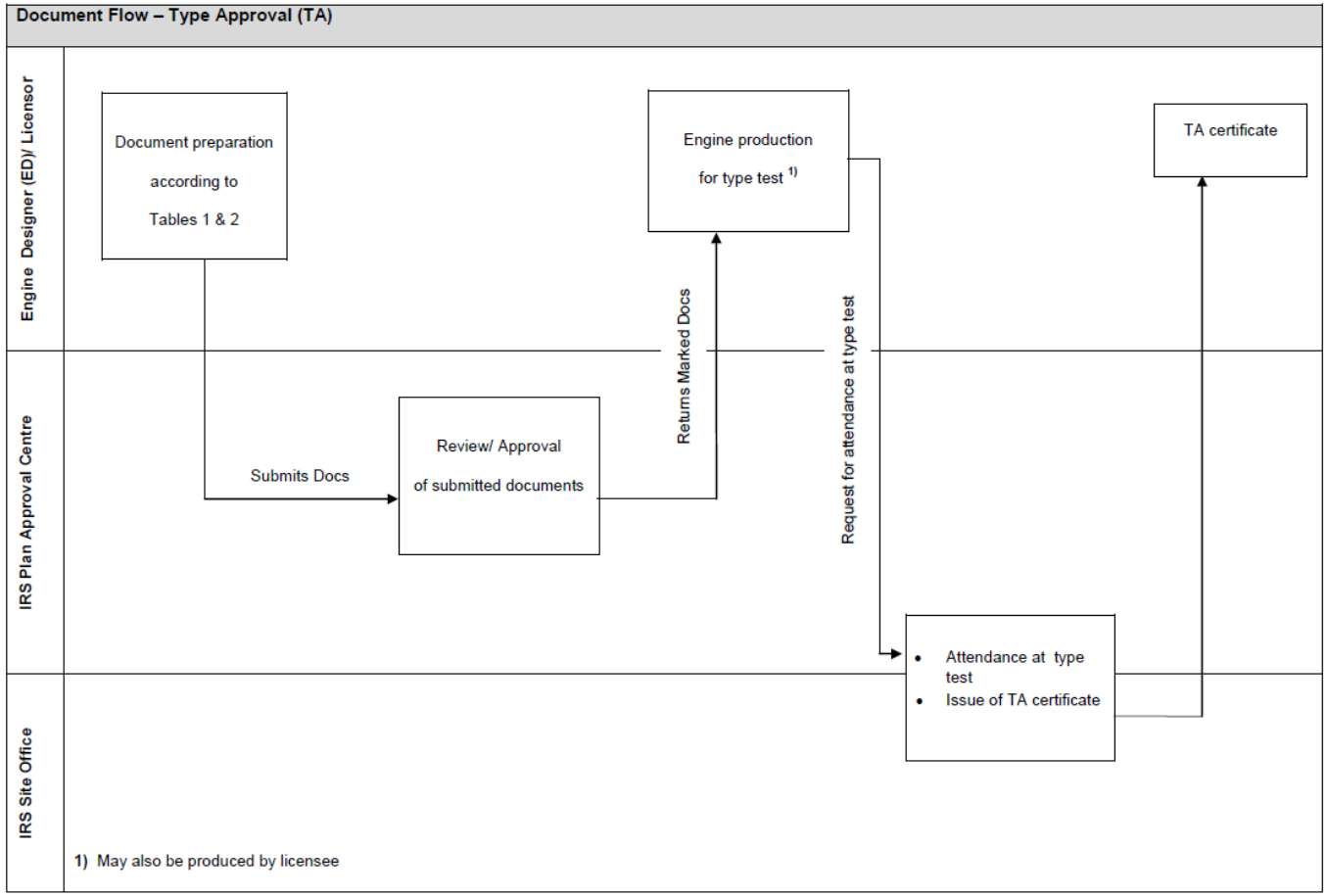


Figure 1 : Type Approval Document Flow

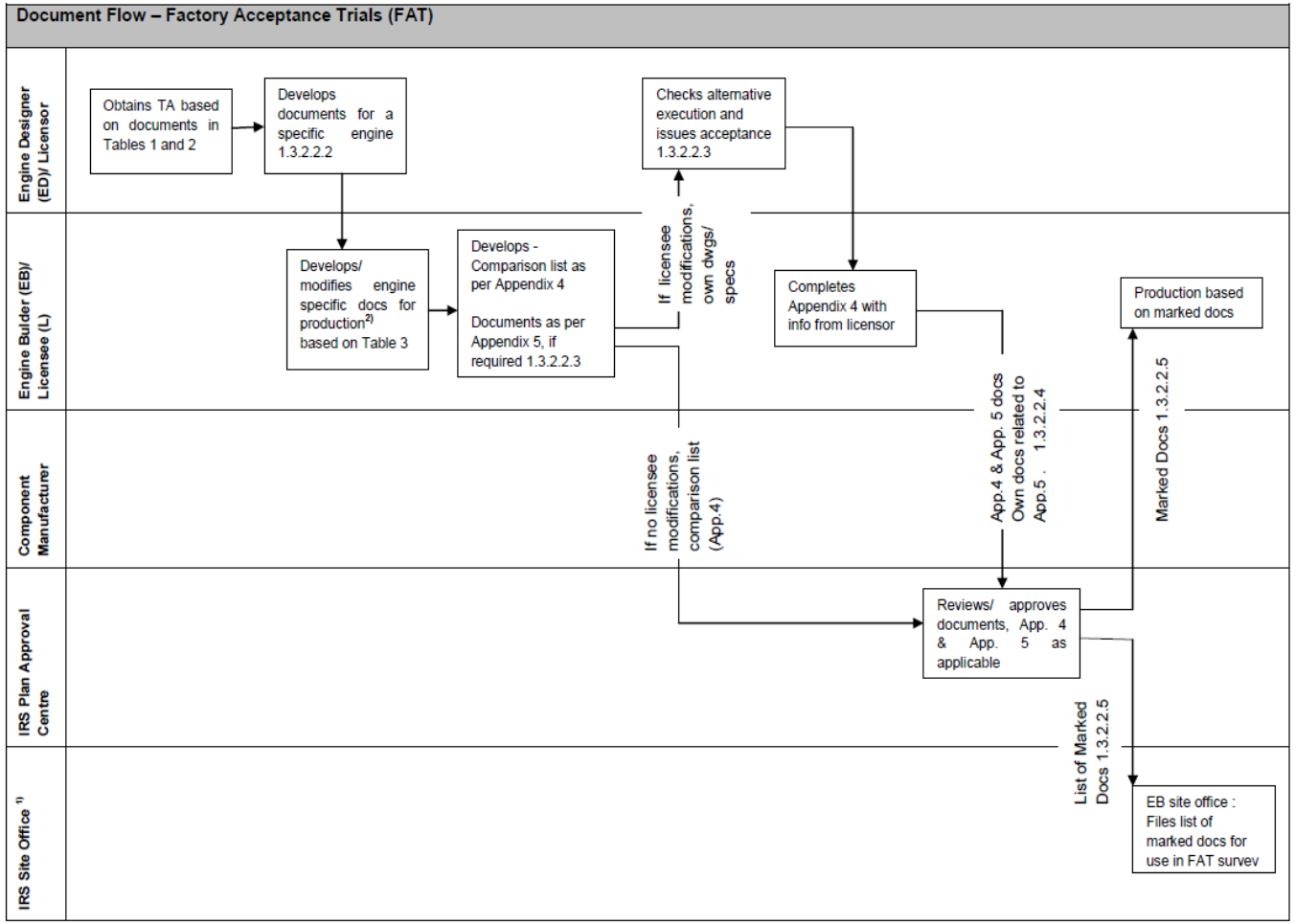


Figure 2 : Engine certificate document flow

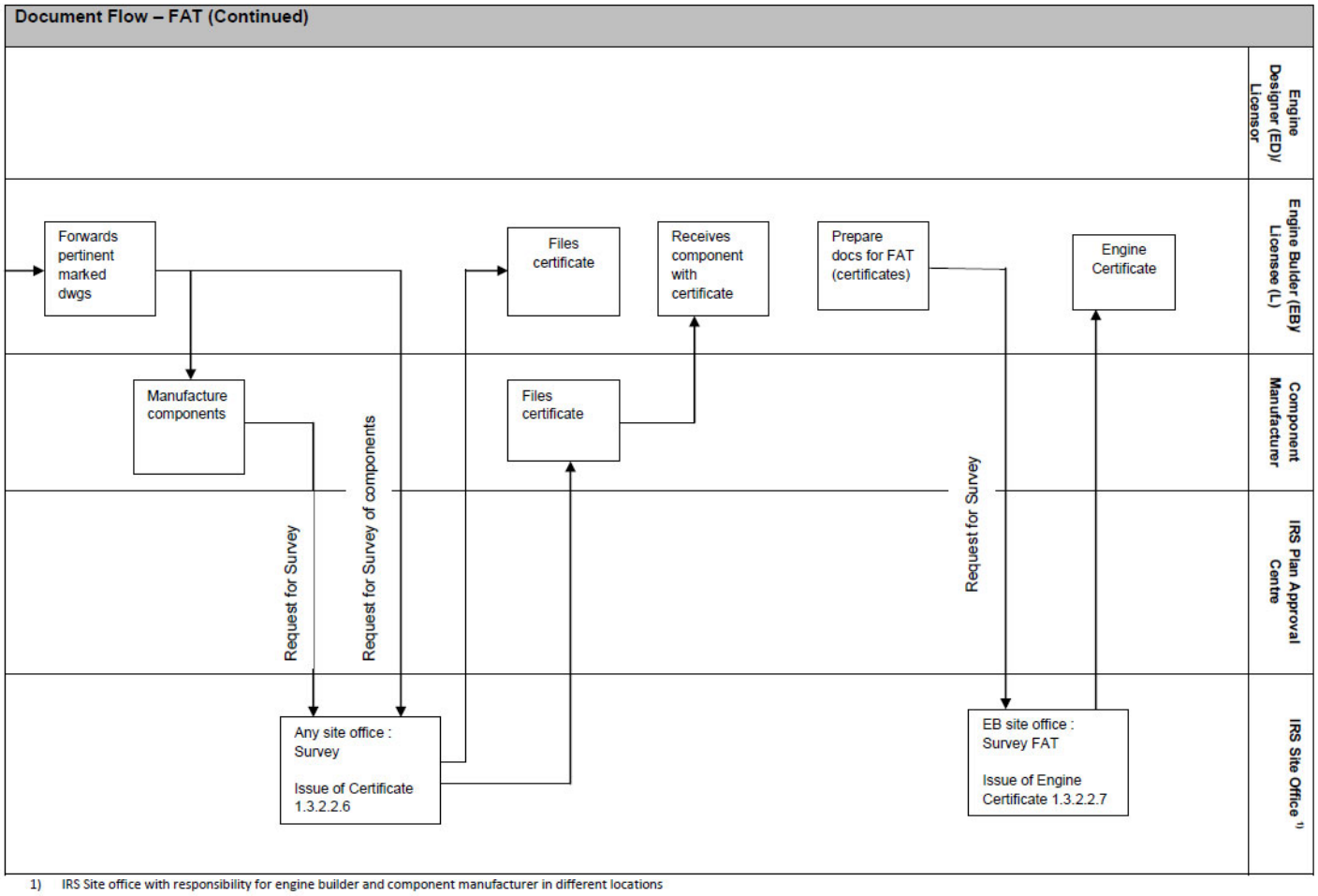


Figure 2 Engine certificate document flow (continued)

Appendix - 3 - Internal Combustion Engine Approval Application Form and Data Sheet

Class Application number (if applicable):

Engine Manufacturer's Application Identification Number:

General Data	
Engine Designer: Contact Person: Address:	Engine Manufacturer(s), Licensee(s) and/or Manufacturing Sites*Name Country

1. Document purpose *(select options from either 1a or 1b)*	
1a. Type Approval Application	
Service Requested ☐ New Type Approval ☐ Renew Type Approval ☐ Amend Type Approval ☐ Design Evaluation ☐ Update TA Supplement ☐ Other	*Required activities†* • *DA, TT, CoP* • *CoP, if design change then amended or new certificate process to be followed* • *DA & CoP, Further TT if previously approved engine has been substantively modified (as required by Section 2)* • *DA, TT, applicable where designer does not have production facilities, Type Approval to be granted to specific production facility once associated CoP has been completed* • *Update to Supplement, only for minor changes not affecting the Type Approval Certificate* • *e.g. National/Statutory Administration requirements i.e. MSC.81(70), as amended, for emergency engines*
For TA Cert amendments or Supplement updates, details of what is to be changed:	
For 'Other', Details of the requirements to be considered:	
1b. Addendum for Individual Engine FAT and Certification	
☐ Individual engine requiring FAT and Certification, only where the performance data for the engine being certified differs from the details provided on the original Type Approval Application. Only section 3b requires completion. Where changes to other sections are necessary, a new Type Approval Application may be required.	

Reference number of *Internal Combustion Engine Approval Application Form* previously submitted and reference number of the Type Approval Certificate.	*(Copy of original application form to be attached to this document)*

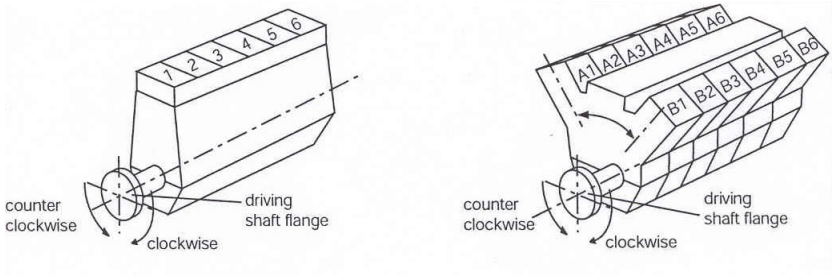
2. Existing documentation			
Previous Class Type Approval Certificate No. or related Design Approval No. *(if applicable)*			
Formerly issued documentation for engine *(E.g. previous type test reports, in-service experience justification reports, etc.)*	Issuing Body:	Document Type:	Document No.:
Existing Certification *(E.g. Manufacturer's quality certification ISO 9001:2015 etc.)*	Issuing Body:	Document Type:	Document No.:

3. Design *(mark all that apply)*				
3a. Engine Particulars:				
Engine Type Manufactured Since‡:			Number of delivered marine engines‡:	
Application	☐ Direct drive Propulsion (☐ Single engine / ☐ Multi-engine installation)		☐ Auxiliary (☐ Aux. Services / ☐ Electric Propulsion)	☐ Emergency
Mechanical Design	☐ 2-stroke	☐ 4-stroke	☐ In-line	☐ Vee (V-angle °) ☐ Other ( )
	☐ Cross-head	☐ Trunk-piston	☐ Reversible	☐ Non-reversible
	Cylinder bore(mm)		Length of piston stroke (mm)	
Supercharging	☐ Without supercharging	☐ With supercharging		
		☐ Without charge air cooling		☐ With charge air cooling
		☐ Constant-pressure charging system		☐ Pulsating pressure charging system
Valve operation	☐ Cam control	☐ Electronic control		
Fuel Injection	☐ Direct injection	☐ Indirect injection	☐ Cam controlled injection	☐ Electronically controlled injection

Fuel Types§ (Classification according to ISO 8216-1:2017)	☐ Marine residual fuel ☐ Marine distillate fuel ☐ Marine distillate fuel ☐ Low flashpoint liquid fuel (specify fuel type) ☐ Gas (specify gas type) ☐ Other (specify) ☐ Dual Fuel (specify combinations of fuels to be used simultaneously)	cSt (Max. kinematic viscosity at 50°C) DMA, DMB, DMC DMX	
3b. Performance Data *(Related to: Barometric pressure 1,000 mbar; Air temperature 45°C; Relative humidity 60%; Seawater temperature 32°C)*			
Model reference No. (if applicable)			
Max. continuous rating	kW/cyl		
Rated speed	1/min		
Mean indicated pressure	MPa		
Mean effective pressure	MPa		
Max. firing pressure	MPa		
Charge air pressure	MPa		
Compression ratio	-		
Mean piston speed	m/s		
3c. Crankshaft			
Design	☐ Solid	☐ Semi-built	☐ Built
Method of Manufacture	☐ Cast	☐ Forged ☐ Slab forged	☐ Approved die forged ☐ Continuous grain flow process
State approved forge/works name:			
Is the crankshaft hardened by an approved process which includes the fillet radii of crankpins and journals? ☐ Yes ☐ No If yes, state process:			

Crankshaft material specification: U.T.S. (N/mm^2) Hardness value (Brinell/Vickers)	 Yield strength (N/mm^2) Elongation (%)
Dimensional Data	
If shrunk on webs, state shrinkage allowance (mm)	Yield strength of crankweb material (N/mm^2)
Centre of gravity of connecting rod from large end centre (mm)	Radius of gyration of connecting rod (mm)
Mass of each crankweb (kg)	Centre of gravity of web from journal axis (mm)
Mass of each counterweight (kg)	Centre of gravity of each counterweight from journal axis (mm)
Axial length of main bearing (mm)	Main bearing working clearance (mm)
Mass of flywheel at driving end (kg)	Mass of flywheel at opposite end (kg)
Nominal alternating torsional stress in crankpin (N/mm^2)	Nominal alternating torsional stress in crank journal (N/mm^2)
Length between centres (Total length)(mm)	

3d. Firing order



State numbering system of cylinders from left to right as per above diagrams (as applicable)

Number of cylinders	Clockwise firing order	Counter-clockwise firing order

4. Engine Ancillary Systems					
4a. Turbochargers	☐ Fitted		☐ Not Fitted		
Turbocharger oil supply by:	☐ Engine lub. oil system		☐ TC internal lub. oil system		
No. of cylinders	No. of aux blowers	No. of charge air coolers	No. of TC	TC manufacturer & type	TC type approval certificate No.
				/ / / / / /	

4b. Speed governor			
Engine application (Main/Aux/Emergency)	Manufacturer / type	Mode of operation	Type approval cert. No. (if electric / electronic gov.)
	/ / /		

4c. Overspeed protection	
Independent overspeed protection available ☐ Yes ☐ No	Mode of operation:
Manufacturer / type, if electronic: /	Type approval certificate No.

4d. Electronic systems	
Engine control and management system *Note: use Remarks section to identify when a different engine control system will be used for Type Test*	
Hardware: Manufacturer & Model: /	Type approval certificate No.
Software: Name & Version: /	Software conformity certificate No.
Additional electronic system 1: Manufacturer & type: /	System function: Type approval certificate No.
Additional electronic system 2: Manufacturer & type: /	System function: Type approval certificate No.
Additional electronic system 3: Manufacturer & type: /	System function: Type approval certificate No.

4e. Starting System
Type:

4f. Safety devices/functions			
A flame arrestor or a bursting disk is installed in the starting air system:	before each starting valve	☐ Yes	☐ No
	in the starting air manifold	☐ Yes	☐ No

Crankcase relief valves available ☐ Yes ☐ No Manufacturer / type: / Type approval certificate No.				
No. of cyl.	Total crankcase gross volume incl. attachments (m^3)	Type & size (mm) of relief valve	Relief area per relief valve (mm^2)	No. of relief valves
		/ / / /		
Method used for detection of potentially explosive crankcase condition: ☐ Oil mist detector: Manufacturer / type: / Type approval certificate No.				
☐ Alternative method: *(mark all that apply)*	☐ crankcase pressure monitoring ☐ oil splash temperature monitoring	☐ bearing temperature monitoring ☐ recirculation arrangements	☐ other:	
Cylinder overpressure warning device available ☐ Yes ☐ No Type: Opening pressure (bar):				
4g. Attached ancillary equipment *(Mark all that apply)*				
Engine driven pumps: ☐ Main lubricating oil pump ☐ Sea cooling water pump ☐ LT-fresh cooling water pump ☐ HT-fresh cooling water pump ☐ Fuel oil booster pump ☐ Hydraulic oil pump ☐ Other ( )				
Engine attached motor driven pumps: ☐ Lubricating oil pump ☐ Cooling fresh water pump ☐ Fuel oil booster pump ☐ Hydraulic oil pump ☐ Other ( )				
Engine attached cooler or heater: ☐ Lubricating oil cooler ☐ Lubricating oil heater ☐ Fuel oil valve cooler ☐ Hydraulic oil cooler ☐ Cooling fresh water cooler				
Engine attached filter: Lubricating oil filter ☐ Single ☐ Duplex ☐ Automatic Fuel oil filter ☐ Single ☐ Duplex ☐ Automatic				

5. Inclination limits *(engine operation is safeguarded under the following limits)*	Athwartships		Fore-and-aft	
	Static	Dynamic	Static	Dynamic
Main & Auxiliary machinery	☐ 15.0°	☐ 22.5°	☐ 5.0°	☐ 7.5°
Emergency machinery	☐ 22.5°	☐ 22.5°	☐ 10.0°	☐ 10.0°
Emergency machinery on ships for the carriage of liquefied gas and liquid chemicals	☐ 30.0°	☐ 30.0°		

6. Main engine emergency operation		
At failure of one auxiliary blower, engine can be started and operated at partial load	☐ Yes	☐ No
At failure of one turbocharger, engine operation can be continued	☐ Yes	☐ No

7. References: *Additional Information Attached to Application*	
Document Name/Number	Summary of information contained in document

8. Further Remarks:

* All parties that affect the final complete engine (e.g. manufacture, modify, adjust) are to be listed. All sites where such work is carried out may be required to complete CoP assessment.

† DA = Design Appraisal, TT = Type Test, CoP = Assessment of Conformity of Production. See ‘Definitions’ at the end of this application form for more information.

‡ Only in case of TA Extension.

§ See ‘Definitions’ at the end of this application form for more information.

Completed By: Signat _____

Company:

Job Title: Stamp:

Date:

Definitions:

Design Appraisal: Evaluation of all relevant plans, calculations and documents related to the design to determine compliance with IRS' technical requirements. This includes requirements for all associated ancillary equipment and systems essential for the safe operation of the engine i.e. the Complete Engine. The Design Appraisal is recorded on a Supplement to the Type Approval Certificate.

Type Testing requires satisfactory completion of testing of the Complete Engine against the requirements of the Classification Societies' applicable engine Type Testing programme (based on minimum requirements of Section 2). Type testing is only applicable to the first in series; all engines are to complete factory acceptance and shipboard trials as defined by Section 5.

Design Evaluation Certification may be granted upon satisfactory completion of Design Appraisal and Type Testing.

Assessment of Conformity of Production means the assessment of quality assurance, manufacturing facilities and processes and testing facilities, to confirm the manufacturer's capability to repeatedly produce the complete engine in accordance with the approved and type tested design.

Type Approval Certification will be granted upon satisfactory completion of Design Appraisal, Type Testing and assessment of Conformity of Production of the complete engine. The Type Approval Certificate will incorporate outputs from the Design Appraisal, the Type Test and the Assessment of Conformity of Production.

Complete Engine includes the control system and all ancillary systems and equipment referred to in the Rules that are used for safe operation of the engine and for which there are rule requirements, this includes systems allowing the use of different fuel types. The exact list of components/items that will need to be tested in together with the bare engine will depend on the specific design of the engine, its control system and the fuel(s) used but may include, but are not limited to, the following:

(a) Turbocharger(s)
(b) Crankcase explosion relief devices
(c) Oil mist detection and alarm devices
(d) Piping
(e) Electronic monitoring and control system(s) – software and hardware
(f) Fuel management system (where dual fuel arrangements are fitted)
(g) Engine driven pumps
(h) Engine mounted filters

Fuel Types: All fuels that the engine is designed to operate with are to be identified on the application form as this may have impact on the requirements that are applicable for Design Appraisal and the scope of the tests required for Type Testing. Where the engine is to operate in a Dual Fuel mode, the combinations of fuel types are to be detailed. E.g. Natural Gas + DMA, Natural Gas + Marine Residual Fuel, the specific details of each fuel are to be provided as indicated in the relevant rows of the Fuel Types part of section 3a of this form.

Appendix 4 - Tabular Listing of Licensor's and Licensee's Drawing and Data

Licensee:_____ Licensor:_____
Licensee Engine No. :_____Engine type:_____

No.	Components or System	Licensor			Licensee		Has Design been modified by Licensee?		If Yes, indicate following information	
		Dwg. No. & Title	Rev. No.	Date of Class Approval or Review	Dwg. No.	Rev. No.	Yes	No	Identification of Alternative approved by Licensor	Date of Class Approval or Review of Licensee Dwg.
1										
2										
3										
4										
5										
6										
7										
8										
9 ...										

I attest the above information to be correct and accurate.

Person in Charge (Licensee): _____ _____
Printed Name **Signature**

Date:_____

Appendix 5 Sample Template for Confirmation of the Licensor's Acceptance of Licensee's Modifications

<table>
<tr><td colspan="5">Engine Licensee Proposed Alternative to Licensor's Design</td></tr>
<tr><td colspan="5">Licensee information</td></tr>
<tr><td>Licensee:</td><td colspan="2"></td><td>Ref No.:</td><td></td></tr>
<tr><td>Description:</td><td colspan="2"></td><td>Info No.:</td><td></td></tr>
<tr><td>Engine type:</td><td colspan="2"></td><td>Main Section:</td><td></td></tr>
<tr><td>Engine No.:</td><td colspan="2"></td><td>Plant Id.:</td><td></td></tr>
<tr><td colspan="5">Design Spec: ☐ General ☐ Specific Nos:</td></tr>
<tr><td>Licensor design:</td><td colspan="2">State relevant part or drawing. numbers. Insert drawing clips or pictures.
Add any relevant information</td><td colspan="2">Licensee Proposed Alternative</td></tr>
<tr><td colspan="2"></td><td colspan="3">For example:

• Differences in geometry
• Differences in the functionality
• Material
• Hardness
• Surface condition
• Alternative standard
• Licensee production information introduced on the drawing
• Weldings or castings
• etc.</td></tr>
<tr><td>Reason:
☐ Licensee's production
☐ Sub-supplier's production
☐ Cost down
☐ Tools</td><td>Interchangeability w. licensor design

☐ Yes ☐ No</td><td>Non-conformity Report Research, Assessment, Evaluation

☐ NCR ☐ RAE</td><td colspan="2">Certified by licensee:
Initials:
Date:</td></tr>
<tr><td colspan="5">Licensor comments</td></tr>
<tr><td colspan="2">LoAE:
☐ Accepted as alternative execution
(Licensor undertakes responsibility)
☐ No objection ☐ Not acceptable
(Licensee undertakes responsibility)</td><td colspan="2">NCR:
☐ Approved
☐ Conditionally approved
☐ Rejected</td><td>Certified by licensor:
Initials:
Date:</td></tr>
<tr><td>Licensor ref.:</td><td colspan="3"></td><td>Date:</td></tr>
<tr><td>Licensee ref.:</td><td colspan="3"></td><td>Date:</td></tr>
</table>

Section 2

Type Testing of I.C. Engines

2.1 General

2.1.1 Type approval of I.C. engine types consists of drawing approval, specification approval, conformity of production, approval of type testing programme, type testing of engines, review of the obtained results, and the issuance of the Type Approval Certificate. The maximum period of validity of a Type Approval Certificate is 5 years. The requirements for drawing approval and specification approval of engines and components are specified in separate Sections, as applicable.

2.1.2 For the purpose of this Section, the following definitions apply:

Low-Speed Engines means diesel engines having a rated speed of less than 300 rpm.

Medium-Speed Engines means diesel engines having a rated speed of 300 rpm and above, but less than 1400 rpm.

High-Speed Engines means diesel engines having a rated speed of 1400 rpm or above.

2.2 Objectives

2.2.1 The type testing, documented in this Section, is to be arranged to represent typical foreseen service load profiles, as specified by the engine builder, as well as to cover for required margins due to fatigue scatter and reasonably foreseen in-service deterioration.

2.2.2 This applies to:

- Parts subjected to high cycle fatigue (HCF) such as connecting rods, cams, rollers and spring tuned dampers where higher stresses may be provided by means of elevated injection pressure, cylinder maximum pressure, etc.

- Parts subjected to low cycle fatigue (LCF) such as “hot” parts when load profiles such as idle - full load - idle (with steep ramps) are frequently used.

- Operation of the engine at limits as defined by its specified alarm system, such as running at maximum permissible power with the lowest permissible oil pressure and/or highest permissible oil inlet temperature.

2.3 Validity

2.3.1 Type testing is required for every new engine type intended for installation onboard ships subject to classification.

2.3.2 A type test carried out for a particular type of engine at any place of manufacture will be accepted for all engines of the same type built by licensees or the licensor, subject to each place of manufacture being found to be acceptable to IRS.

2.3.3 A type of engine is defined by:

- bore and stroke
- injection method (direct or indirect)
- valve and injection operation (by cams or electronically controlled)
- kind of fuel (liquid, dual-fuel, gaseous)
- working cycle (4-stroke, 2-stroke)
- turbo-charging system (pulsating or constant pressure)
- the charging air cooling system (e.g. with or without intercooler)
- cylinder arrangement (in-line or V) **1)**
- cylinder power, speed and cylinder pressures **2)**

Notes:

1) One type test will be considered adequate to cover a range of different numbers of cylinders. However, a type test of an in-line engine may not always cover the V-version. Separate type tests may be required for the V-version, depending on case-to-case basis. On the other hand, a type test of a V-engine covers the in-line engines, unless the bmep is higher.

   Items such as axial crankshaft vibration, torsional vibration in camshaft drives, and crankshafts, etc. may vary considerably with the number of cylinders and may influence the choice of engine to be selected for type testing.

2) The engine is type approved up to the tested ratings and pressures (100% corresponding to MCR).

   Provided documentary evidence of successful service experience with the classified rating of 100% is submitted, an increase (if design approved*) may be permitted without a new type test if the increase from the type tested engine is within:

   - 5% of the maximum combustion pressure, or
   - 5% of the mean effective pressure, or
   - 5% of the rpm

Providing maximum power is not increased by more than 10%, an increase of maximum approved power may be permitted without a new type test provided engineering analysis and evidence of successful service experience in similar field applications (even if the application is not classified) or documentation of internal testing are submitted if the increase from the type tested engine is within:

- 10% of the maximum combustion pressure, or
- 10% of the mean effective pressure, or
- 10% of the rpm

* Only crankshaft calculation and crankshaft drawings, if modified.

De-rated engine

If an engine has been design approved, and internal testing per Stage A is documented to a rating higher than the one type tested, the Type Approval may be extended to the increased power/mep/rpm upon submission of an Extended Delivery Test Report at:

- Test at over speed (only if nominal speed has increased)
- Rated power, i.e. 100% output at 100% torque and 100% speed corresponding to load point 1., 2 measurements with one running hour in between
- Maximum permissible torque (normally 110%) at 100% speed corresponding to load point 3 or maximum permissible power (normally 110%) and speed according to nominal propeller curve corresponding to load point 3a., ½ hour
- 100% power at maximum permissible speed corresponding to load point 2, ½ hour

Integration Test

An integration test demonstrating that the response of the complete mechanical, hydraulic and electronic system is as predicted maybe carried out for acceptance of sub-systems (Turbo Charger, Engine Control System, Dual Fuel, Exhaust Gas treatment…) separately approved. The scope of these tests is to be proposed by the designer/licensor taking into account of impact on engine.

2.4 Safety Precautions

2.4.1 Before any test run is carried out, all relevant equipment for the safety of attending personnel is to be made available by the manufacturer/shipyard and is to be operational, and its correct functioning is to be verified.

2.4.2 This applies especially to crankcase explosive conditions protection, but also over-speed protection and any other shut down function.

2.4.3 The inspection for jacketing of high-pressure fuel oil lines and proper screening of pipe connections (as required in 2.8.9 fire measures) is also to be carried out before the test runs.

2.4.4 Interlock test of turning gear is to be performed when installed.

2.5 Test programme

2.5.1 The type testing is divided into 3 stages:

.1 Stage A - internal tests.
This includes some of the testing made during the engine development, function testing, and collection of measured parameters and records of testing hours. The results of testing required by IRS or stipulated by the designer are to be presented to IRS before starting stage B.

.2 Stage B - witnessed tests.
This is the testing made in the presence of attending Surveyors.

.3 Stage C - component inspection.
This is the inspection of engine parts to the extent as required on case-to-case basis.

2.5.2 The complete type testing program is subject to approval by IRS. The extent the Surveyor's attendance is to be agreed in each case, but at least during stage B and C.

2.5.3 Testing prior to the witnessed type testing (stage B and C), is also considered as a part of the complete type testing program.

2.5.4 Upon completion of complete type testing (stage A through C), a type test report is to be submitted to IRS for review. The type test report is to contain:

- overall description of tests performed during stage A. Records are to be kept by the builders QA management for presentation to IRS.

- detailed description of the load and functional tests conducted during stage B.

- inspection results from stage C.

2.5.5 As required in 2.2 the type testing is to substantiate the capability of the design and its suitability for the intended operation. Special testing such as LCF and endurance testing will normally be conducted during stage A.

2.5.6 High speed engines for marine use are normally to be subjected to an endurance test of 100 hours at full load. Omission or simplification of the type test may be considered for the type approval of engines with long service experience from non-marine fields or for the extension of type approval of engines of a well-known type, in excess of the limits given in 2.3.

Propulsion engines for high speed vessels that may be used for frequent load changes from idle to full are normally to be tested with at least 500 cycles (idle - full load - idle) using the steepest load ramp that the control system (or operation manual if not automatically controlled) permits. The duration at each end is to be sufficient for reaching stable temperatures of the hot parts.

2.6 Measurements and recordings

2.6.1 During all testing the ambient conditions (air temperature, air pressure and humidity) are to be recorded.

2.6.2 As a minimum, the following engine data are to be measured and recorded:

- Engine r.p.m.
- Torque
- Maximum combustion pressure for each cylinder [1)]
- Mean indicated pressure for each cylinder [1)]
- Charging air pressure and temperature
- Exhaust gas temperature
- Fuel rack position or similar parameter related to engine load
- Turbocharger speed
- All engine parameters that are required for control and monitoring for the intended use (propulsion, auxiliary, emergency).

Notes:

1) For engines where the standard production cylinder heads are not designed for such measurements, a special cylinder head made for this purpose may be used. In such a case, the measurements may be carried out as part of Stage A and are to be properly documented. Where deemed necessary e.g. for dual fuel engines, the measurement of maximum combustion pressure and mean indicated pressure may be carried out by indirect means, provided the reliability of the method is documented.

   Calibration records for the instrumentation used to collect data as listed above are to be presented to - and reviewed by the attending Surveyor.

   Additional measurements may be required in connection with the design assessment.

2.7 Stage A - internal tests

2.7.1 During the internal tests, the engine is to be operated at the load points important for the engine designer and the pertaining operating values are to be recorded. The load conditions to be tested are also to include the testing specified in the applicable type approval programme.

2.7.2 At least the following conditions are to be tested:

- Normal case:

The load points 25%, 50%, 75%, 100% and 110% of the maximum rated power for continuous operation, to be made along the normal (theoretical) propeller curve and at constant speed for propulsion engines (if applicable mode of operation i.e. driving controllable pitch propellers), and at constant speed for engines intended for generator sets including a test at no load and rated speed.

- The limit points of the permissible operating range. These limit points are to be defined by the engine manufacturer.

- For high speed engines, the 100 hr full load test and the low cycle fatigue test apply as required in connection with the design assessment.

- Specific tests of parts of the engine, required by IRS or stipulated by the designer.

2.8 Stage B - witnessed tests

2.8.1 The tests listed below are to be carried out in the presence of a Surveyor. The achieved results are to be recorded and signed by the attending Surveyor after the type test is completed.

2.8.2 The over-speed test is to be carried out and is to demonstrate that the engine is not damaged by an actual engine overspeed within the overspeed shutdown system set-point. This test may be carried out at the manufacturer’s choice either with or without load during the speed overshoot.

2.8.3 Load points

The engine is to be operated according to the power and speed diagram (see Figure 2.8.3). The data to be measured and recorded when testing the engine at the various load points have to include all engine parameters listed in 2.6. The operating time per load point depends on the engine size (achievement of steady state condition) and on the time for collection of the operating values. Normally, an operating time of 0.5 hour can be assumed per load point, however sufficient time should be allowed for visual inspection by the Surveyor.

2.8.4 The load points are:

- Rated power (MCR), i.e. 100% output at 100% torque and 100% speed corresponding to load point 1, normally for 2 hours with data collection with an interval of 1 hour. If operation of the engine at limits as defined by its specified alarm system (e.g. at alarm levels of lub oil pressure and inlet temperature) is required, the test should be made here.

- 100% power at maximum permissible speed corresponding to load point 2.

- Maximum permissible torque (at least and normally 110%) at 100% speed corresponding to load at point 3, or maximum permissible power (at least and normally 110%) and 103.2% speed according to the nominal propeller curve corresponding to load point 3a. Load point 3a applies to engines only driving fixed pitch propellers or water jets. Load point 3 applies to all other purposes.

Load point 3 (or 3a as applicable) is to be replaced with a load that corresponds to the specified overload and duration approved for intermittent use. This applies where such overload rating exceeds 110% of MCR. Where the approved intermittent overload rating is less than 110% of MCR, subject overload rating has to replace the load point at 100% of MCR. In such case the load point at 110% of MCR remains.

- Minimum permissible speed at 100% torque, corresponding to load point 4.

- Minimum permissible speed at 90% torque corresponding to load point 5. (Applicable to propulsion engines only).

- Part loads e.g. 75%, 50% and 25% of rated power and speed according to nominal propeller curve (i.e. 90.8%, 79.3% and 62.9% speed) corresponding to points 6, 7 and 8 or at constant rated speed setting corresponding to points 9, 10 and 11, depending on the intended application of the engine.

- Crosshead engines not restricted for use with C.P. propellers are to be tested with no load at the associated maximum permissible engine speed.

2.8.5 During all these load points, engine parameters are to be within the specified and approved values.

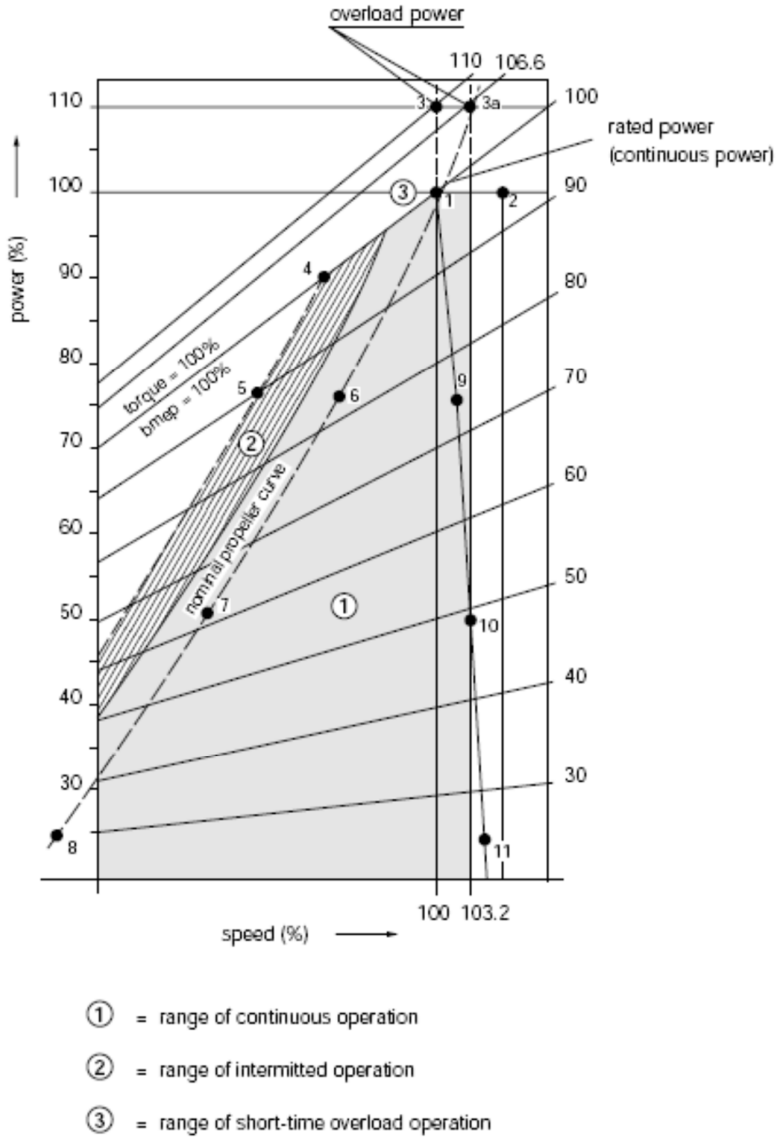


Fig.2.8.3 : Load points

2.8.6 Operation with damaged turbocharger

For 2-stroke propulsion engines, the achievable continuous output is to be determined in the case of turbocharger damage.

Engines intended for single propulsion with a fixed pitch propeller are to be able to run continuously at a speed (r.p.m.) of 40% of full speed along the theoretical propeller curve when one turbocharger is out of operation. (The test can be performed by either by-passing the turbocharger, fixing the turbocharger rotor shaft or removing the rotor.)

2.8.7 Functional tests

- Verification of the lowest specified propulsion engine speed according to the nominal propeller curve as specified by the engine designer (even though it works on a water-brake). During this operation, no alarm shall occur.

- Starting tests, for non-reversible engines and/or starting and reversing tests, for reversible engines, for the purpose of determining the minimum air pressure and the consumption for a start.

- Governor tests: tests for compliance with Pt.4/Ch.4/ Sec.4 of the Rules, are to be carried out.

2.8.8 Integration test

For electronically controlled diesel engines, integration tests are to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests is to be agreed with IRS for selected cases based on the FMEA required in Section 1.

2.8.9 Fire protection measures

Verification of compliance with requirements for jacketing of high-pressure fuel oil lines, screening of pipe connections in piping containing flammable liquids and insulation of hot surfaces:

- The engine is to be inspected for jacketing of high-pressure fuel oil lines, including the system for the detection of leakage, and proper screening of pipe connections in piping containing flammable liquids.

- Proper insulation of hot surfaces is to be verified while running the engine at 100% load, alternatively at the overload approved for intermittent use. Readings of surface temperatures are to be done by use of Infrared Thermoscanning Equipment. Equivalent measurement equipment may be used when so approved by IRS. Readings obtained are to be randomly verified by use of contact thermometers.

2.9 Stage C - Opening up for Inspections

2.9.1 The crankshaft deflections are to be measured in the specified (by designer) condition (except for engines where no specification exists).

2.9.2 High speed engines for marine use are normally to be stripped down for a complete inspection after the type test.

2.9.3 For all the other engines, after the test run the components of one cylinder for in-line engines and two cylinders for V-engines are to be presented for inspection as follows (engines with long service experience from non-marine fields can have a reduced extent of opening):

- piston removed and dismantled

- crosshead bearing dismantled

- guide planes

- connecting rod bearings (big and small end) dismantled (special attention to serrations and fretting on contact surfaces with the bearing backsides)
- main bearing dismantled

- cylinder liner in the installed condition

- cylinder head, valves disassembled

- cam drive gear or chain, camshaft and crankcase with opened covers. (The engine must be turnable by turning gear for this inspection.)

2.9.4 For V-engines, the cylinder units are to be selected from both cylinder banks and different crank throws.

2.9.5 If deemed necessary by the surveyor, further dismantling of the engine may be required.

Section 3

Certification of Engine Components

3.1 General

3.1.1 The engine manufacturer is to have a quality control system that is suitable for the actual engine types to be certified by IRS. The quality control system is also to apply to any sub-suppliers. IRS reserves the right to review the system or parts thereof. Materials and components are to be produced in compliance with all the applicable production and quality instructions specified by the engine manufacturer. IRS requires that certain parts are verified and documented by means of Society Certificate (SC), Work Certificate (W) or Test Report (TR).

3.1.2 Society Certificate (SC)

This is a document issued by IRS stating:

- conformity with Rule requirements.
- that the tests and inspections have been carried out on the finished certified component itself, or on samples taken from earlier stages in the production of the component, when applicable.
- that the inspection and tests were performed in the presence of the Surveyor or in accordance with special agreements, i.e. Alternative Certification Scheme (ACS).

3.1.3 Work's Certificate (W)

This is a document signed by the manufacturer stating:

- conformity with requirements.
- that the tests and inspections have been carried out on the finished certified component itself, or on samples taken from earlier stages in the production of the component, when applicable.
- that the tests were witnessed and signed by a qualified representative of the applicable department of the manufacturer.

A Work's Certificate may be considered equivalent to a Society Certificate and endorsed by IRS if:

- the test was witnessed by IRS Surveyor; or
- an ACS agreement is in place between IRS and the manufacturer or material supplier; or
- the Work's certificate is supported by tests carried out by an accredited third party that is accepted by IRS and independent from the manufacturer and/or material supplier.

3.1.4 Test Report (TR)

This is a document signed by the manufacturer stating:

- conformity with requirements.
- that the tests and inspections have been carried out on samples from the current production batch.

3.1.5 The documents above are used for product documentation as well as for documentation of single inspections such as crack detection, dimensional check, etc. If agreed to by IRS, the documentation of single tests and inspections may also be arranged by filling in results on a control sheet following the component through the production.

3.1.6 The Surveyor is to review the TR and W for compliance with the agreed or approved specifications. SC means that the Surveyor also witnesses the testing, batch or individual, unless an ACS provides other arrangements.

3.1.7 The manufacturer is not exempted from responsibility for any relevant tests and inspections of those parts for which documentation is not explicitly requested by IRS. The manufacturing process and equipment is to be set up and maintained in such a way that all materials and components can be consistently produced to the required standard. This includes production and assembly lines, machining units, special tools and devices, assembly and testing rigs as well as all lifting and transportation devices.

3.2. Parts to be documented

3.2.1 The extent of parts to be documented depends on the type of engine, engine size and criticality of the part.

3.2.2 Symbols used are listed in Table 3.2.2 (a). A summary of the required documentation for the engine components is listed in Table 3.2.2 (b).

Table 3.2.2 (a) : Symbols used in Table 3.2.2 (b)	
Symbol	Description
C	chemical composition
CD	crack detection by MPI or DP
CH	crosshead engines
D	cylinder bore diameter (mm)
GJL	gray cast iron
GJS	spheroidal graphite cast iron
GS	cast steel
M	mechanical properties
SC	society certificate
TR	test report
UT	ultrasonic testing
W	work certificate
X	visual examination of accessible surfaces by the Surveyor

3.2.3 Components and materials not specified in Table 3.2.2(b), will be specially considered based upon full details being submitted by manufacturer and reviewed.

Table 3.2.2 (b) : Summary of required documentation for engine components

Item	Part [4), 5), 6), 7),8)]	Material properties [1)]	Non-destructive examination [2)]	Hydraulic testing [3)]	Dimensional inspection, including surface condition	Visual inspection (surveyor)	Applicable to engines:	Component certificate
1	**Welded bedplate**	W(C+M)	W(UT+CD)			fit-up + post-welding	All	SC
2	**Bearing transverse girders GS**	W(C+M)	W(UT+CD)			X	All	SC
3	**Welded frame box**	W(C+M)	W(UT+CD)			fit-up + post-welding	All	SC
4	**Cylinder block GJL**			W[10)]			>400 kW/cyl	
5	**Cylinder block GJS**			W[10)]			>400 kW/cyl	
6	**Welded cylinder frames**	W(C+M)	W(UT+CD)			fit-up + post-welding	CH	SC
7	**Engine block GJL**			W[10)]			>400 kW/cyl	
8	**Engine block GJS**	W(M)		W[10)]			>400 kW/cyl	
9	**Cylinder liner**	W(C+M)		W[10)]			D>300mm	
10	**Cylinder head GJL**			W			D>300mm	
11	**Cylinder head GJS**			W			D>300mm	
12	**Cylinder head GS**	W(C+M)	W(UT+CD)	W		X	D>300mm	SC
13	**Forged cylinder head**	W(C+M)	W(UT+CD)	W		X	D>300mm	SC
14	**Piston crown GS**	W(C+M)	W(UT+CD)			X	D>400mm	SC
15	**Forged piston crown**	W(C+M)	W(UT+CD)			X	D>400mm	SC
16	**Crankshaft: made in one piece**	SC(C+M)	W(UT+CD)		W	Random, of fillets and oil bores	All	SC

Table 3.2.2 (b) : (Contd.)

Item	Part [4), 5), 6), 7),8)]	Material properties [1)]	Non-destructive examination [2)]	Hydraulic testing [3)]	Dimensional inspection, including surface condition	Visual inspection (surveyor)	Applicable to engines:	Component certificate
17	**Semi-built Crankshaft(Crankthrow, forged main journal and journals with flange)**	SC(C+M)	W(UT+CD)		W	Random, of fillet and shrink fittings	All	SC
18	**Exhaust gas valve cage**			W			CH	
19	**Piston rod**	SC(C+M)	W(UT+CD)			Random	D>400mm CH	SC
20	**Cross head**	SC(C+M)	W(UT+CD)			Random	CH	SC
21	**Connecting rod with cap**	SC(C+M)	W(UT+CD)		W	Random, of all surfaces, in particular those shot peened	All	SC
22	**Coupling bolts for crankshaft**	SC(C+M)	W(UT+CD)		W	Random, of interference fit	All	SC
23	**Bolts and studs for main bearings**	W(C+M)	W(UT+CD)				D>300mm	
24	**Bolts and studs for cylinder heads**	W(C+M)	W(UT+CD)				D>300mm	
25	**Bolts and studs for connecting rods**	W(C+M)	W(UT+CD)		TR of thread making		D>300mm	
26	**Tie rod**	W(C+M)	W(UT+CD)		TR of thread making	Random	CH	SC

Table 3.2.2 (b) : (Contd.)

Item	Part [4), 5), 6), 7),8)]	Material properties [1)]	Non-destructive examination [2)]	Hydraulic testing [3)]	Dimensional inspection, including surface condition	Visual inspection (surveyor)	Applicable to engines:	Component certificate
27	**High pressure fuel injection pump body**	W(C+M)		W			D>300mm	
		W(C+M)		TR			D≤300mm	
28	**High pressure fuel injection valves (only for those not autofretted)**			W			D>300mm	
				TR			D≤300mm	
29	**High pressure fuel injection pipes including common fuel rail**	W(C+M)		W for those that are not autofretted			D>300mm	
		W(C+M)		TR for those that are not autofretted			D≤300mm	
30	**High pressure common servo oil system**	W(C+M)		W			D>300mm	
		W(C+M)		TR			D≤300mm	
31	**Cooler, both sides[9)]**	W(C+M)		W			D>300mm	

Table 3.2.2 (b) : (Contd.)

Item	Part [4), 5), 6), 7),8)]	Material properties [1)]	Non-destructive examination [2)]	Hydraulic testing [3)]	Dimensional inspection, including surface condition	Visual inspection (surveyor)	Applicable to engines:	Component certificate
32	**Accumulator**	W(C+M)		W			All engines with accumulators with a capacity of >0.5 l	
33	**Piping, pumps, actuators, etc. for hydraulic drive of valves, if applicable**	W(C+M)		W			>800 kW/cyl	
34	**Engine driven pumps (oil, water, fuel, bilge) other than pumps referred to in item 27 and 33**			W			>800 kW/cyl	
35	**Bearings for main, crosshead, and crankpin**	TR(C)	TR (UT for full contact between base material and bearing metal)		W		>800 kW/cyl	

Table 3.2.2 (b) : (Contd.)

Notes :

1. Material properties include chemical composition and mechanical properties, and also surface treatment such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force).

2. Non-destructive examination means e.g. ultrasonic testing, crack detection by MPI or DP.

3. Hydraulic testing is applied on the water/oil side of the component. Items are to be tested by hydraulic pressure at the pressure equal to 1.5 times the maximum working pressure. High pressure parts of the fuel injection system are to be tested by hydraulic pressure at the pressure equal to 1.5 maximum working pressure or maximum working pressure plus 300 bar, whichever is the less. Where design or testing features may require modification of these test requirements, special consideration may be given.

4. Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this Table apply except where alternative requirements are explicitly given elsewhere in the Rules.

5. For turbochargers, see Section 4.

6. Crankcase explosion relief valves are to be type tested in accordance with Classification Note: “Type testing procedure for Crankcase Explosion Relief Valves” and documented according to Pt.4/Ch.4 of the Rules.

7. Oil mist detection systems are to be type tested in accordance with Classification Note: “Type testing procedure for Crankcase Oil Mist Detection and Alarm Equipment” and documented according to Pt.4/Ch.4 of the Rules.

8. For speed governor and over-speed protective devices, see Pt 4/ Ch4/ Sec.4 of the Rules.

9. Charge air coolers need only be tested on the water side.

10. Hydraulic testing is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

Section 4

Turbochargers

4.1 Scope

4.1.1 These requirements are applicable for turbochargers with regard to design approval, type testing and certification and their matching on engines.

Turbochargers are to be type approved, either separately or as a part of an engine. The requirements are written for exhaust gas driven turbochargers, but apply in principle also for engine driven chargers.

4.1.2 The requirements escalate with the size of the turbochargers. The parameter for size is the engine power (at MCR) supplied by a group of cylinders served by the actual turbocharger, (e.g. for a V-engine with one turbocharger for each bank the size is half of the total engine power).

4.1.3 Turbochargers are categorised in three groups depending on served power by cylinder groups with:

- Category A: ≤ 1000 [kW]
- Category B: > 1000 [kW] and ≤ 2500 [kW]
- Category C: > 2500 [kW

4.2 Documentation to be submitted

4.2.1 Category A:

On request

- Containment test report.
- Cross sectional drawing with principal dimensions and names of components.
- Test program.

4.2.2 Category B and C:

- Cross sectional drawing with principal dimensions and materials of housing components for containment evaluation.
- Documentation of containment in the event of disc fracture, see 4.3.2.

- Operational data and limitations as:
- Maximum permissible operating speed (rpm)
  - Alarm level for over-speed
  - Maximum permissible exhaust gas temperature before turbine
  - Alarm level for exhaust gas temperature before turbine
  - Minimum lubrication oil inlet pressure
  - Lubrication oil inlet pressure low alarm set point
  - Maximum lubrication oil outlet temperature
  - Lubrication oil outlet temperature high alarm set point
  - Maximum permissible vibration levels, i.e. self- and externally generated vibration

(Alarm levels may be equal to permissible limits but shall not be reached when operating the engine at 110% power or at any approved intermittent overload beyond the 110%.)

- Arrangement of lubrication system, all variants within a range.
- Type test reports.
- Test program.

4.2.3 Category C:

- Drawings of the housing and rotating parts including details of blade fixing.
- Material specifications (chemical composition and mechanical properties) of all parts mentioned above.
- Welding details and welding procedure of above mentioned parts, if applicable.
- Documentation*) of safe torque transmission when the disc is connected to the shaft by an interference fit, see 4.3.3.
- Information on expected lifespan, considering creep, low cycle fatigue and high cycle fatigue.
- Operation and maintenance manuals*).

*) Applicable to two sizes in a generic range of turbochargers.

4.3 Design requirements and corresponding type testing

4.3.1 General

4.3.1.1 The turbochargers are to be designed to operate under conditions given in Part 4, Chapter 1, Cl 1.7 of IRS Rules and Regulations for the Construction and Classification of Steel Ships. The component lifetime and the alarm level for speed are to be based on 45°C air inlet temperature.

4.3.1.2 The air inlet of turbochargers is to be fitted with a filter.

4.3.2 Containment

4.3.2.1 Turbochargers are to fulfill containment in the event of a rotor burst. This means that at a rotor burst no part may penetrate the casing of the turbocharger or escape through the air intake. For documentation purposes (test/calculation), it is to be assumed that the discs disintegrate in the worst possible way.

4.3.2.2 For category B and C, containment is to be documented by testing. Fulfillment of this requirement can be awarded to a generic range of turbochargers based on testing of one specific unit. Testing of a large unit is preferred as this is considered conservative for all smaller units in the generic range. In any case, it is to be documented (e.g. by calculation) that the selected test unit really is representative for the whole generic range.

4.3.3.3 The minimum test speeds, relative to the maximum permissible operating speed, are:

- For the compressor: 120%.
- For the turbine: 140% or the natural burst speed, whichever is lower.

4.3.2.4 Containment tests are to be performed at working temperature.

4.3.2.5 A numerical analysis (simulation) of sufficient containment integrity of the casing based on calculations by means of a simulation model may be accepted in lieu of the practical containment test, provided that:

- The numerical simulation model has been tested and its suitability/accuracy has been proven by direct comparison between calculation results and the practical containment test for a reference application (reference containment test). This test is to be performed at least once by the manufacturer for acceptance of the numerical simulation method in lieu of tests.

- The corresponding numerical simulation for the containment is performed for the same speeds as specified for the containment test.

- Material properties for high-speed deformations are to be applied in the numeric simulation. The correlation between normal properties and the properties at the pertinent deformation speed are to be substantiated.

- The design of the turbocharger regarding geometry and kinematics is similar to the turbocharger that was used for the reference containment test. In general, totally new designs will call for a new reference containment test.

4.3.3 Disc-shaft shrinkage fit

4.3.3.1 Applicable to Category C

4.3.3.2 In cases where the disc is connected to the shaft with interference fit, calculations are to substantiate safe torque transmission during all relevant operating conditions such as maximum speed, maximum torque and maximum temperature gradient combined with minimum shrinkage amount.

4.3.4 Type testing

4.3.4.1 Applicable to Categories B and C

4.3.4.2 The type test for a generic range of turbochargers may be carried out either on an engine (for which the turbocharger is foreseen) or in a test rig.

4.3.4.3 Turbochargers are to be subjected to at least 500 load cycles at the limits of operation. This test may be waived if the turbocharger together with the engine is subjected to this kind of low cycle testing, see Section 2.

4.3.4.4 The suitability of the turbocharger for such kind of operation is to be preliminarily stated by the manufacturer.

4.3.4.5 The rotor vibration characteristics are to be measured and recorded in order to identify possible sub-synchronous vibrations and resonances.

4.3.4.6 The type test is to be completed by a hot running test at maximum permissible speed combined with maximum permissible temperature for at least one hour. After this test, the turbocharger is to be opened for examination, with focus on possible rubbing and the bearing conditions.

4.3.4.7 The extent of the surveyor’s presence during the various parts of the type tests would be subject to agreement between the manufacturer and IRS.

4.4 Certification

4.4.1 The manufacturer is to adhere to a quality system designed to ensure that the designer's specifications are met, and that manufacturing is in accordance with the approved drawings.

4.4.2 For category C, this is to be verified by means of periodic product audits of an Alternative Certification Scheme (ACS), as detailed in Pt.1, Ch.1, Sec.1 of the Rules for Construction and Classification of Steel Ships.

4.4.3 These audits are to focus on:

- Chemical composition of material for the rotating parts.
- Mechanical properties of the material of a representative specimen for the rotating parts and the casing.
- UT and crack detection of rotating parts.
- Dimensional inspection of rotating parts.
- Rotor balancing.
- Hydraulic testing of cooling spaces to 4 bars or 1.5 times maximum working pressure, whichever is higher.
- Overspeed test of all compressor wheels for duration of 3 minutes at either 20% above alarm level speed at room temperature or 10% above alarm level speed at 45°C inlet temperature when tested in the actual housing with the corresponding pressure ratio. The over-speed test may be waived for forged wheels that are individually controlled by an approved non-destructive method.

4.4.4 Turbochargers are to be delivered with:

- For category C, an IRS certificate; which at a minimum cites the applicable type approval and the ACS, when ACS applies.
- For category B, a work's certificate; which at a minimum cites the applicable type approval, which includes production assessment.

4.4.5 The same applies to replacement of rotating parts and casing.

4.4.6 Alternatively to the above periodic product audits, individual certification of a turbocharger and its parts would be subject to agreement between the manufacturer and IRS. However, such individual certification of category C turbocharger and its parts is also to be based on test requirements specified in the above mentioned bullet points.

4.5 Alarms & Monitoring

4.5.1 For all turbochargers of Categories B and C, indications and alarms as listed in the table below are required to be provided.

4.5.2 Indications may be provided at either local or remote locations.

Table 4.5.1 : Indications and Alarms

Pos.	Monitored Parameters	Category of Turbochargers				Notes
		B		C		
		Alarm	Indication	Alarm	Indication	
1	Speed	High (4)	X (4)	High (4)	X (4)	
2	Exhaust gas at each turbocharger inlet, temperature	high (1)	X (1)	high	X	High temp. alarms for each cylinder at engine is acceptable (2)
3	Lub. oil at turbocharger outlet, temperature			high	X	If not forced system, oil temperature near bearings
4	Lub. oil at turbocharger inlet, pressure	low	X	low	X	Only for forced lubrication systems (3)

Notes:

(1) For Category B turbochargers, the exhaust gas temperature may be alternatively monitored at the turbocharger outlet, provided that the alarm level is set to a safe level for the turbine and that correlation between inlet and outlet temperatures is substantiated.

(2) Alarm and indication of the exhaust gas temperature at turbocharger inlet may be waived if alarm and indication for individual exhaust gas temperature is provided for each cylinder and the alarm level is set to a value safe for the turbocharger.

(3) Separate sensors are to be provided if the lubrication oil system of the turbocharger is not integrated with the lubrication oil system of the diesel engine or if it is separated by a throttle or pressure reduction valve from the diesel engine lubrication oil system.

(4) On turbocharging systems where turbochargers are activated sequentially, speed monitoring is not required for the turbocharger(s) being activated last in the sequence, provided all turbochargers share the same intake air filter and they are not fitted with waste gates.

Section 5

Dual Fuel and Gas Fuel Engines

5.1 Scope

5.1.1 Types of Engines

5.1.1.1 The following requirements are applicable to trunk piston internal combustion engines supplied with low pressure natural gas as fuel. Engines can be either dual fuel (hereinafter referred to as DF engines) or gas fuel only engines (hereinafter referred to as GF engines).

5.1.1.2 Gas can be introduced as follows:

• into the air inlet manifold, scavenge space, or cylinder air inlet channel port; or

• mixed with air before the turbo-charger (“pre-mixed engines”).

5.1.1.3 The gas/ air mixture in the cylinder can be ignited by the combustion of a certain amount of fuel (pilot injection) or by extraneous ignition (sparking plug).

5.1.1.4 The requirements in this Section cover the following applications, but are not limited to:

- Mechanical propulsion
- Generating sets intended for main propulsion and auxiliary applications.
- Single engine or multi-engine installations.

5.2 Documents and drawings to be submitted

5.2.1 In addition to the documents in Section 1, the following documents are to be submitted for the approval of DF and GF engines:

Table 5.2.1: Documentation to be submitted for approval of DF and GF engines	
No.	**Item**
1	Schematic layout or other equivalent documents of gas system on the engine
2	Gas piping system (including double-walled arrangement where applicable)
3	Parts for gas admission system[3]
4	Arrangement of explosion relief valves (crankcase[1], charge air manifold, exhaust gas manifold) as applicable
5	List of certified safe equipment and evidence of relevant certification
6	Safety concept (for information)
7	Report of the risk analysis[2] (for information)
8	Gas specification (for information)
Documents and drawings to be submitted for the approval of DF engine	
9	Schematic layout or other equivalent documents of fuel oil system (main and pilot fuel systems) on the engine
10	Shielding of high pressure fuel pipes for pilot fuel system, assembly
11	High pressure parts for pilot fuel oil injection system[3]
Documents and drawings to be submitted for the approval of GF engine	
12	Ignition system
Notes : 1. If required by Section 1. 2. See 5.3 3. The documentation to contain specification of pressures, pipe dimensions and materials.	

5.2.2 IRS may request further documents/ drawings to be submitted, where considered necessary.

5.3 Risk Analysis

5.3.1 Scope of the risk analysis

5.3.1.1 The risk analysis is to address:

- a failure or malfunction of any system or component involved in the gas operation of the engine
- a gas leakage downstream of the gas valve unit
- the safety of the engine in case of emergency shutdown or blackout, when running on gas

- the inter-actions between the gas fuel system and the engine.

Note: With regard to the scope of the risk analysis it is to be noted that failures in systems external to the engine, such as fuel storage or fuel gas supply systems, may require action from the engine control and monitoring system in the event of an alarm or fault condition. Conversely failures in these external systems may, from the vessel perspective, require additional safety actions from those required by the engine limited risk analysis required by this Section.

5.3.2 Form of the risk analysis

5.3.2.1 The risk analysis is to be carried out in accordance with ISO 31010:2009: Risk management - Risk assessment techniques, or other recognized standards.

5.3.2 The required analysis is to be based on the single failure concept, which means that only one failure needs to be considered at the same time. Both detectable and non-detectable failures are to be considered. Consequences failures, i.e. failures of any component directly caused by a single failure of another component, are also to be considered.

5.3.3 Procedure for the risk analysis

5.3.3.1 The risk analysis is to:

a) Identify all the possible failures in the concerned equipment and systems which could lead to:

(i) the presence of gas in components or locations not designed for such purpose, and/or

(ii) ignition, fire or explosion.

b) Evaluate the consequences

c) Where necessary, identify the failure detection method

d) Where the risk cannot be eliminated, identify the corrective measures:

(i) in the system design, such as:

- redundancies
- safety devices, monitoring or alarm provisions which permit restricted operation of the system

(ii) in the system operation, such as:

- initiation of the redundancy
- activation of an alternative mode of operation.

5.3.3.2 The results of the risk analysis are to be documented.

5.3.4 Equipment and systems to be analyzed

5.3.4.1 The risk analysis required for engines is to cover at least the following aspects:

a) failure of the gas-related systems or components, in particular:

- gas piping and its enclosure, where provided
- cylinder gas supply valves

(**Note**: Failures of the gas supply components not located directly on the engine, such as block-and-bleed valves and other components of the Gas Valve Unit (GVU), are not to be considered in the analysis.)

b) failure of the ignition system (oil fuel pilot injection or sparking plugs)

c) failure of the air to fuel ratio control system (charge air by-pass, gas pressure control valve, etc.)

d) for engines where gas is injected upstream of the turbocharger compressor, failure of a component likely to result in a source of ignition (hot spots)

e) failure of the gas combustion or abnormal combustion (misfiring, knocking)

f) failure of the engine monitoring, control and safety systems

Note: Where engines incorporate electronic control systems, a failure mode and effects analysis (FMEA) is to be carried out in accordance with Footnote 5 of Table 1 in Section 1.

g) abnormal presence of gas in engine components (e.g. air inlet manifold and exhaust manifold of DF or GF engines) and in the external systems connected to the engines (e.g. exhaust duct).

h) changes of operating modes for DF engines.

i) hazard potential for crankcase fuel gas accumulation, for engines where the space below the piston is in direct communication with the crankcase, refer to Pt. 5, Ch. 35, Sec. 10, 10.3.1.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships.*

5.4 Design Requirements

5.4.1 General Principles

.1 The manufacturer is to declare the allowable gas composition limits for the engine and the minimum and (if applicable) maximum methane number.

.2 Components containing or likely to contain gas are to be designed to:

a) minimize the risk of fire and explosion so as to demonstrate an appropriate level of safety commensurate with that of an oil-fueled engine;

b) mitigate the consequences of a possible explosion to a level providing a tolerable degree of residual risk, due to the strength of the component(s) or the fitting of suitable pressure relief devices of an approved type.

Also refer to Pt. 5, Ch. 35, Sec. 10, 10.2 and 10.3 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

Note:

1. Discharge from pressure relief devices is to prevent the passage of flame to the machinery space and be arranged such that the discharge does not endanger personnel or damage other engine components or systems.

2. Relief devices are to be fitted with a flame arrester.

5.4.2 Specific design requirements for gas piping, charge air system, exhaust system, inerting of engine crankcase, gas ignition, control, monitoring and alarms etc. may be referred in Pt.4, Ch. 4, Sec. 4, 4.14 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

5.5 Type Testing

5.5.1 Type approval of DF and GF engines is to be carried out in accordance with Section 2, taking into account the additional requirements below:

5.5.2 Type of engine

.1 In addition to the criteria given in Sec. 2, 2.3.3, the type of engine is defined by the following:

- gas admission method (direct cylinder injection, charge air space or pre-mixed)
- gas supply valve operation (mechanical or electronically controlled)
- ignition system (pilot injection, spark ignition, glow plug or gas self-ignition)
- ignition system (mechanical or electronically controlled)

5.5.3 Safety Precautions

In addition to the safety precautions indicated in Section 2, 2.4, measures to verify that gas fuel piping on engine is gas tight are to be carried out prior to start-up of the engine.

5.5.4 Test programme

.1 The type testing of the engine is to be carried out in accordance with Section 2, 2.5.

.2 For DF engines, the load tests referred to in Section 2, 2.5 are to be carried out in gas mode at the different percentages of the maximum power available in gas mode (See Pt. 4, Ch. 4, 4.14.5.1 of the *Rules and Regulations for the Construction and Classification of Steel Ships*).

3 The influence of the methane number and LHV of the fuel gas is not required to be verified during the Stage B type tests. It is however to be justified by the engine designer through internal tests or calculations and documented in the type approval test report.

5.5.5 Measurements and records

.1 In addition to the measurements and records required in Section 2, 2.6, the following engine data are to be measured and recorded:

- Each fuel index for gas and diesel as applicable (or equivalent reading)
- Gas pressure and temperature at the inlet of the gas manifold
- Gas concentration in the crankcase

.2 Additional measurements may be required in connection with the design assessment.

5.5.6 Stage A – Internal Tests

.1 In addition to tests required in Section 2, 2.7, the following conditions are to be tested:

- DF engines are to run the load points defined in Section 2, 2.7 in both gas and diesel modes (with and without pilot injection in service) as found applicable for the engine type.
- For DF engines with variable liquid / gas ratio, the load tests are to be carried out at different ratios between the minimum and the maximum allowable values.
- For DF engines, switch over between gas and diesel modes are to be tested at different loads.

5.5.7 Stage B – Witnessed Tests

5.5.7.1 General

a) Gas engines are to undergo the different tests required in Section 2, 2.8.

b) In case of DF engine, all load points must be run in both gas and diesel modes that apply for the engine type as defined by the engine designer (see 5.5.1.4). This also applies to the overspeed test.

c) In case of DF engines with variable liquid / gas ratio, the load tests are to be carried out at different ratios between the minimum and the maximum allowable values.

5.5.7.2 Functional Tests

.1 In addition to the functional tests required in Section 2, 2.8.3, the following tests are to be carried out:

- For DF engines, the lowest specified speed is to be verified in diesel mode and gas mode.
- For DF engines, switch over between gas and diesel modes are to be tested at different loads.
- The efficiency of the ventilation arrangement of the double walled gas piping system is to be verified.
- Simulation of a gas leakage in way of a cylinder gas supply valve.

.2 Engines intended to produce electrical power are to be tested as follows:

- Capability to take sudden load and loss of load in accordance with the provisions of Pt. 4, Ch. 4, 4.7.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*).

- For GF and premixed engines, the influences of LHV, methane number and ambient conditions on the dynamic load response test results are to be theoretically determined and specified in the test report. Referring to the limitations as specified in 5.4.1.2, the margin for satisfying dynamic load response is to be determined.

Note:

1. For DF engines, switchover to oil fuel during the test is acceptable.

2. Application of electrical load in more than 2 load steps can be permitted in the conditions specified in Pt. 4, Ch. 4, 4.7.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

5.5.7.3 Integration Tests

.1 GF and DF engines are to undergo integration tests to verify that the response of the complete mechanical, hydraulic and electronic engine system is as predicted for all intended operational modes. The scope of these tests is to be agreed with IRS for selected cases based on the risk analysis required in 5.3, and is to at least include the following incidents:

- Failure of ignition (spark ignition or pilot injection systems), both for one-cylinder unit and common system failure

- Failure of a cylinder gas supply valve

- Failure of the combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.)

- Abnormal gas pressure

- Abnormal gas temperature (**Note** – This test may be carried out using a simulation signal of the temperature).

5.5.8 Stage C – Component Inspection

.1 Component inspection is to be carried out in accordance with the provisions of Section 2, 2.9. The components to be inspected after the test run are to also include the following:

- gas supply valve including pre-chamber as found applicable
- spark igniter (for GF engines)
- pilot fuel injection valve (for DF engines)

5.6 Factory Acceptance Trials

5.6.1 Requirements for factory acceptance trials of DF and GF engines are indicated in Pt.4, Ch. 4, Sec. 4, 4.13.6.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

5.7 Shipboard Trials

5.7.1 Requirements for shipboard trials of DF and GF engines are indicated in Pt.4, Ch. 4, Sec. 4, 4.13.6.3 of the *Rules and Regulations for the Construction and Classification of Steel Ships.*

Section 6

Methanol fueled Engines

6.1 Application

6.1.1 The requirements in this Section are applicable to approval of methanol fueled engines and are to be read in conjunction with the requirements of Sections 1 to 5, (as applicable).

6.1.2 In addition, the IRS *Guidelines on Methanol Fueled Vessels* are also to be referred for other safety requirements for methanol fueled ships. The basic philosophy of the guidelines is to provide provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems in ships using methanol as fuel to minimize the risk to the ship, its crew and the environment, having regard to the nature of the fuels involved.

6.1.3 Currently, most methanol fueled engines in use are dual-fuel engines (i.e. methanol along with oil fuel). In conjunction with the requirements indicated in the previous sections (Sections 1 to 5), the approval of methanol fueled engines would generally include the requirements of this section.

6.2 Functional Requirements

6.2.1 The safety, reliability and dependability of the systems are to be equivalent to that achieved with new and comparable conventional oil-fueled main and auxiliary machinery.

6.2.2 The design philosophy of the engine is to ensure that risk reducing measures and safety actions for the fuel installation do not lead to an unacceptable loss of power.

6.2.3 The engine and its components are to be designed, constructed, installed, operated and protected to ensure safe and reliable operation.

6.2.4 Suitable control, alarm, monitoring and shutdown systems are to be provided to ensure safe and reliable operation.

6.2.5 The technical documentation provided for the engine is to permit an assessment of the engine and its components to design standards used and the principles related to safety, availability, maintainability and reliability.

6.2.6 A single failure in the engine or its components is not to lead to an unsafe or unreliable situation.

6.3 General

6.3.1 All engine components and engine related systems are to be designed in such a way that fire and explosion risks are minimized.

6.3.2 Engine components containing methanol fuel are to be effectively sealed to prevent leakage of fuel into the machinery space.

6.3.3 For engines where the space below the piston is in direct communication with the crankcase a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase is to be carried out and reflected in the safety concept of the engine.

6.3.4 Special attention is to be paid to the corrosive nature of methanol while selecting materials used in engine components. To avoid corrosion, stainless steel and teflon is recommended. Metals like lead, zinc, copper, aluminium and magnesium, as well as some elastomers, plastics and rubber are not to be used in contact with methanol.

6.3.5 Methanol is a solvent and can also form acids during combustion which could lead to higher demands on lubricant additives and more frequent oil changes.

6.3.6 The low lubricity of methanol requires additives in the fuel to avoid problems with diesel type fuel pumps and injectors, unless customized engine units are used.

6.4 Dual-Fuel Engines

6.4.1 In case of shutoff of the methanol supply, the engines are to be capable of continuous operation by oil fuel only without interruption.

6.4.2 An automatic system is to be fitted to change over from methanol mode to oil fuel-only mode and vice versa with minimum fluctuation of the engine power. Acceptable reliability is to be demonstrated through testing.

6.4.3 In the case of unstable operation on engines when methanol firing, the engine is to automatically changeover to oil fuel mode. A possibility for manual changeover is also to be provided.

6.4.4 In case of an emergency stop or a normal stop the methanol fuel is to be automatically shut off not later than the pilot oil fuel. It shall not be possible to shut off the pilot oil fuel without first or simultaneously closing the fuel supply to each cylinder or to the complete engine.

6.5 Single Fuel Engines

6.5.1 In case of a normal stop or an emergency shutdown, the methanol fuel supply is to be shut off not later than the ignition source. It is not to be possible to shut off the ignition source without first or simultaneously closing the fuel supply to each cylinder or to the complete engine.

6.6 Engine Types

6.6.1 The methanol based engine applications may be as follows:

(a) neat methanol in port fuel injected spark ignited (PFI-SI) engines

(b) neat methanol in direct injected spark ignited (DI-SI) engines

(c) neat methanol in partially premixed combustion (PPC) engines

(d) additized methanol (blended methanol) in diesel engines

6.7 Documents and drawings to be submitted

6.7.1 The documentation indicated in Section 1 is to be submitted for approval of S.F. engines. In addition to the documents indicated in Section 1, the following are to be submitted for the approval of DF engines:

Table 6.7.1: Documentation to be submitted for approval of DF Engines

No.	Item
1	Schematic layout or other equivalent documents of methanol system on the engine
2	Methanol piping system (including double-walled arrangement where applicable)
3	Arrangement of explosion relief valves (crankcase[1], charge air manifold, exhaust gas manifold) as applicable
4	List of certified safe equipment and evidence of relevant certification
5	Safety concept (for information)
6	Report of the risk analysis[2] (for information)
7	Fuel specification (for information)
8	Schematic layout or other equivalent documents of fuel oil system (main and pilot fuel systems) on the engine
9	Shielding of high pressure fuel pipes for pilot fuel system, assembly
10	High pressure parts for pilot fuel oil injection system[3]

Notes:

1. If required by Section 1.
2. See 6.8
3. The documentation to contain specifications of pressures, pipe dimensions and materials.

6.8 Risk Analysis

6.8.1 Scope of the risk analysis

6.8.1.1 The risk analysis is to address:

- a failure or malfunction of any system or component involved in the methanol operation of the engine
- a methanol leakage
- the safety of the engine in case of emergency shutdown or blackout, when running on methanol
- the inter-actions between the methanol fuel system and the engine.

Note: With regard to the scope of the risk analysis it is to be noted that failures in systems external to the engine, such as methanol fuel storage or methanol fuel supply systems, may require action from the engine control and monitoring system in the event of an alarm or fault condition. Conversely failures in these external systems may, from the vessel perspective, require additional safety actions from those required by the engine limited risk analysis required by this Section.

6.8.2 Form of the risk analysis

6.8.2.1 The risk analysis is to be carried out in accordance with ISO 31010:2009: Risk management - Risk assessment techniques, or other recognized standards.

6.8.2.2 The required analysis is to be based on the single failure concept, which means that only one failure needs to be considered at the same time. Both detectable and non-detectable failures are to be considered. Consequences failures, i.e. failures of any component directly caused by a single failure of another component, are also to be considered.

6.8.3 Procedure for risk analysis

6.8.3.1 The risk analysis is to:

a) Identify all the possible failures in the concerned equipment and systems which could lead to:

(i) the presence of methanol in components or locations not designed for such purpose, and/or

(ii) ignition, fire or explosion.

b) Evaluate the consequences

c) Where necessary, identify the failure detection method

d) Where the risk cannot be eliminated, identify the corrective measures:

(i) in the system design, such as:

• redundancies

• safety devices, monitoring or alarm provisions which permit restricted operation of the system

(ii) in the system operation, such as:

• initiation of the redundancy

• activation of an alternative mode of operation.

6.8.3.2 Equipment and systems to be analyzed

6.8.3.2.1 The risk analysis required for engines is to cover at least the following aspects:

a) failure of the methanol related systems or components

b) failure of the ignition system (oil fuel pilot injection or sparking plugs)

c) failure of the air to fuel ratio control system (charge air by-pass, gas pressure control valve, etc.)

d) failure of a component likely to result in a source of ignition (hot spots)

e) failure of the engine monitoring, control and safety systems

Note: Where engines incorporate electronic control systems, a failure mode and effects analysis (FMEA) is to be carried out in accordance with Footnote 5 of Table 1 in Section 1.

f) abnormal presence of methanol in engine components (e.g. air inlet manifold and exhaust manifold of DF engines) and in the external systems connected to the engines (e.g. exhaust duct).

g) changes of operating modes for DF engines.

h) hazard potential for crankcase fuel gas accumulation, for engines where the space below the piston is in direct communication with the crankcase.

6.9 Type Testing

6.9.1 Type approval of DF and SF engines is to be carried out in accordance with Section 2, taking into account the additional requirements below:
6.9.1.1 Safety Precautions

In addition to the safety precautions indicated in Section 2, 2.4, measures to verify that fuel piping on engine is liquid tight are to be carried out prior to start-up of the engine.

6.9.1.2 Test programme

.1 The type testing of the engine is to be carried out in accordance with Section 2, 2.5.

.2 For DF engines, the load tests referred to in Section 2, 2.5 are to be carried out in methanol mode at the different percentages of the maximum power available (See Pt. 4, Ch. 4, 4.14.5.1 of the *Rules and Regulations for the Construction and Classification of Steel Ships*).

.3 The influence of the methane number and LHV of the fuel is not required to be verified during the Stage B type tests. It is however to be justified by the engine designer through internal tests or calculations and documented in the type approval test report.

6.9.1.3 Measurements and records

.1 In addition to the measurements and records required in Section 2, 2.6, the following engine data are to be measured and recorded:

- Each fuel index for methanol and diesel as applicable (or equivalent reading)
- Methanol pressure and temperature at the inlet of the manifold
- Methanol concentration in the crankcase

.2 Additional measurements may be required in connection with the design assessment.

6.9.1.4 Stage A – Internal Tests

.1 In addition to tests required in Section 2, 2.7, the following conditions are to be tested:

- DF engines are to run the load points defined in Section 2, 2.7 in both methanol and diesel modes (with and without pilot injection in service) as found applicable for the engine type.

• For DF engines with variable diesel / methanol ratio, the load tests are to be carried out at different ratios between the minimum and the maximum allowable values.

• For DF engines, switch over between methanol and diesel modes are to be tested at different loads.

6.9.1.5 Stage B – Witnessed Tests

6.9.1.5.1 General

a) Methanol engines are to undergo the tests required in Section 2, 2.8.

b) In case of DF engine, all load points are to be run in both methanol and diesel modes that apply for the engine type as indicated by the engine designer. This also applies to the overspeed test.

c) In case of DF engines with variable diesel/ methanol ratio, the load tests are to be carried out at different ratios between the minimum and the maximum allowable values.

6.9.1.5.2 Functional Tests

.1 In addition to the functional tests required in Section 2, 2.8.3, the following tests are to be carried out:

• For DF engines, the lowest specified speed is to be verified in diesel mode and methanol mode.

• For DF engines, switch over between methanol and diesel modes are to be tested at different loads.

• The efficiency of the ventilation arrangement of the double walled piping system is to be verified (as applicable).

• Simulation of a methanol leakage in way of a cylinder methanol supply valve.

.2 Engines intended to produce electrical power are to be tested as follows:

• Capability to take sudden load and loss of load in accordance with the provisions of Pt. 4, Ch. 4, 4.7.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*).

• For SF and premixed engines, the influences of LHV, methane number and ambient conditions on the dynamic load response test results are to be theoretically determined and specified in the test report.

Note:

1. For DF engines, switchover to oil fuel during the test is acceptable.

2. Application of electrical load in more than 2 load steps can be permitted in the conditions specified in Pt. 4, Ch. 4, 4.7.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

6.9.1.5.3 Integration Tests

.1 SF and DF engines are to undergo integration tests to verify that the response of the complete mechanical, hydraulic and electronic engine system is as predicted for all intended operational modes. The scope of these tests is to be agreed with IRS for selected cases based on the risk analysis required in 6.8, and is to at least include the following incidents:

- Failure of ignition (spark ignition or pilot injection systems), both for one-cylinder unit and common system failure
- Failure of a cylinder methanol supply valve
- Failure of the combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.)
- Abnormal methanol pressure
- Abnormal methanol temperature (**Note** – This test may be carried out using a simulation signal of the temperature).

6.9.1.6 Stage C – Component Inspection

.1 Component inspection is to be carried out in accordance with the provisions of Section 2, 2.9. The components to be inspected after the test run are to also include the following:

- methanol supply valve including pre-chamber as found applicable
- spark igniter (as applicable)
- pilot fuel injection valve (for DF engines)

6.10 Factory Acceptance Trials and Shipboard Trails

6.10.1 The factory acceptance trials and shipboard trials are to be carried out in accordance with the requirements of Pt.4, Ch.4, Sec. 4 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

6.11 Aspects to be noted/ verified during retrofit/ modifications on existing engines

6.11.1 In case of existing diesel engines being modified to operate on methanol, the following aspects are to be noted:

(a) Apart from the fuel system with pumps, injectors etc. that need to be upgraded, blended methanol (like MD95) require different pistons.

(b) PFI-SI, DI-SI engines are to be fitted with new pistons and cylinder heads adopted for spark plugs.

(c) The dual-fuel engines also need adaptation with new pistons and secondary fueling systems.

(d) The PPC engines need an exhaust gas recirculation (EGR) system and an advanced fuel injection system.

6.11.2 The efficiency of direct injected concepts such as DI-SI, DI-dual fuel and PPC have similar or higher efficiency as diesel engines.

6.11.3 Power levels would be similar to that of diesel engines but with some limitations for the blended methanol concept due to very high compression ratios and for the PFI-SI engine due to risk of knock.

6.11.4 Noise levels in the DI-SI, DI-dual fuel and PFI-SI engines would be lesser than diesel engines. PPC engines would be noisier than diesel engines.

6.11.5 The following may be noted with respect to soot emissions:

(a) Neat methanol fuel will not produce carbon based soot in engine combustion, due to the high oxygen content of methanol.

(b) Soot emissions in Dual-Fuel and DI-Dual-Fuel are lower than for conventional diesel operation, but there would be some emissions as they depend on diesel pilot fuel.

(c) For blended methanol fuels (like MD-95), there would be no soot emissions, but some unburned additives may be seen on particulate filters.

End of Classification Note